PFBR: A Threat to Life

A Critique on the Environmental Impact Assessment
of the Prototype Fast Breeder Reactor
to be constructed at
Kalpakkam, Tamil Nadu, India

R.Ramesh M.B.,B.S.,

DOSE
Kanuvai
Coimbatore,641 108
drramesh65 @ hotmail.com

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This Work is Dedicated
To

Dr.Dhirendara Sharma,

Mr.Nagarjunan,

and to

Mr. K.Chellapandy,
Editor, Purappadu

Preface

Nuclear Industry in India has always been ambitious.That, as far as I am personally concerned, is nothing wrong. It has been receiving a large share of our Research and Development Budget. To be exact,11.1% of the total R&D budget was used by the Department of Atomic Energy in 1996-97. This was 10 times higher than what the Indian Council of Medical Research was recieving (1.1%) or around 100 times higher than what the Ministry of Non-Conventional Energy Sources used that year(0.1%). Among the Scientific establishments in India, it was the military related organisations that were recieving the maximum share.The Department of Space (DOS), and the Defence Research and Development Organisation (DRDO) were using 22.3% and 30.7% of the total R&D money on that year. This along with the share of the DAE works out to be around 64.1% of the total R&D money.

When they are given this exemplary budgetary preference and pampering, they naturally have to show the results for the money they have been using. The performance of the DAE, despite having received a large chunk of the R&D money, have been dismal as far as the amount of Electricity produced by them is concerned. What are the reasons for this poor performance, we do not know exactly; but of late, we are forced to doubt the scientific credentials of the Department itself; we are slowly being forced to think, that probably the lack of a true Scientific spirit in the department might be the reason for all this poor performance.

Friends of mine have argued of course, earlier, that if the DAE is a truly scientific organisation why should it need its 1964 Atomic Energy Act which allows secrecy? How can any research activity that is not peer reviewed be considered scientific? All this is answered by invoking the idea that the Security of the Nation will be at stake if all this is discussed and reviewed openly. OK.That might be true. That has made me speechless earlier and even now; but how can I make myself believe that the scientists at the DAE are pursuing Science despite clothing and shielding themselves by these secretive laws? It is this question that has been nagging me for the past few years.

And a few months back I got an opportunity to analyse this in detail. This is in connection with the Prototype Fast Breeder Reactor (PFBR) that is going to come up at Kalpakkam. After the Bhopal Gas Leak Tragedy the Indian Government has decided to ask the supposedly hazardous industries to do an Environmental Impact Assessment for getting a licence to operate. It is this decision which went into the EIA laws of 1994, and 1997. In this new scenario, the Indra Gandhi Centre for Atomic Research (IGCAR) which is responsible for the PFBR project, was also asked to commission an EIA for its upcoming project. This EIA was awarded to the Metal Company MECON of Ranchi in 1998 and the company submitted the first report to the IGCAR in Oct,2000.

This is the First nuclear reactor of the country for which an EIA has been conducted. As this is the first one, and as the DAE is one among the three top sharers of the science R&D budget, my expectation was that this EIA would be a model EIA, that shall be followed by other similar industries of the country in the future. As this is an ace scientific institution of the country, I naturally expected, that this institution would have kept very strict standards for conducting this study.

But I have found to my dismay, that this EIA has been done in a very unscientific way. The scientists of the MECON have even quoted scientifically wrong facts. They have not analysed vital issues like the Health Impacts of the project. I, reflexly expected the IGCAR to discard the study as an unscientific act; but to my dismay, and disbelief, IGCAR is going forward for a Public Hearing on the project, and is asking the TamilNadu Pollution Control Board to give its approval based on this “MECON” study! I am unable to believe even now that all this is happening.

Why did the IGCAR accept an unscientific impact study in the first place? If it is an Altar of Science how can it do that? If the AEC considers itself that it is not a temple of science, then what legitimacy does it have to regularly consume 11-15% of the Nation’s R&D budget?

This is the time that the Pollution Control Board should act strictly in the spirit of Science and

reject this MECON EIA as an unscientific and a biased one. Its act will not only be a trend setter, thus making a great advance in the country's occupational and environmental health scenario, but also will correct an ace institution slipping away from the path of Science. This will definitely save that institution in the long run even if it does not get the sugar candy called the PFBR today.

This is the spirit with which I started this work. Friends at "DOSE" have helped me in the background research and in publishing. Thanks to all of you.

I would like to thank here the librarian of the Geological Society of India at Bangalore for having helped me with the back volumes of their magazine.

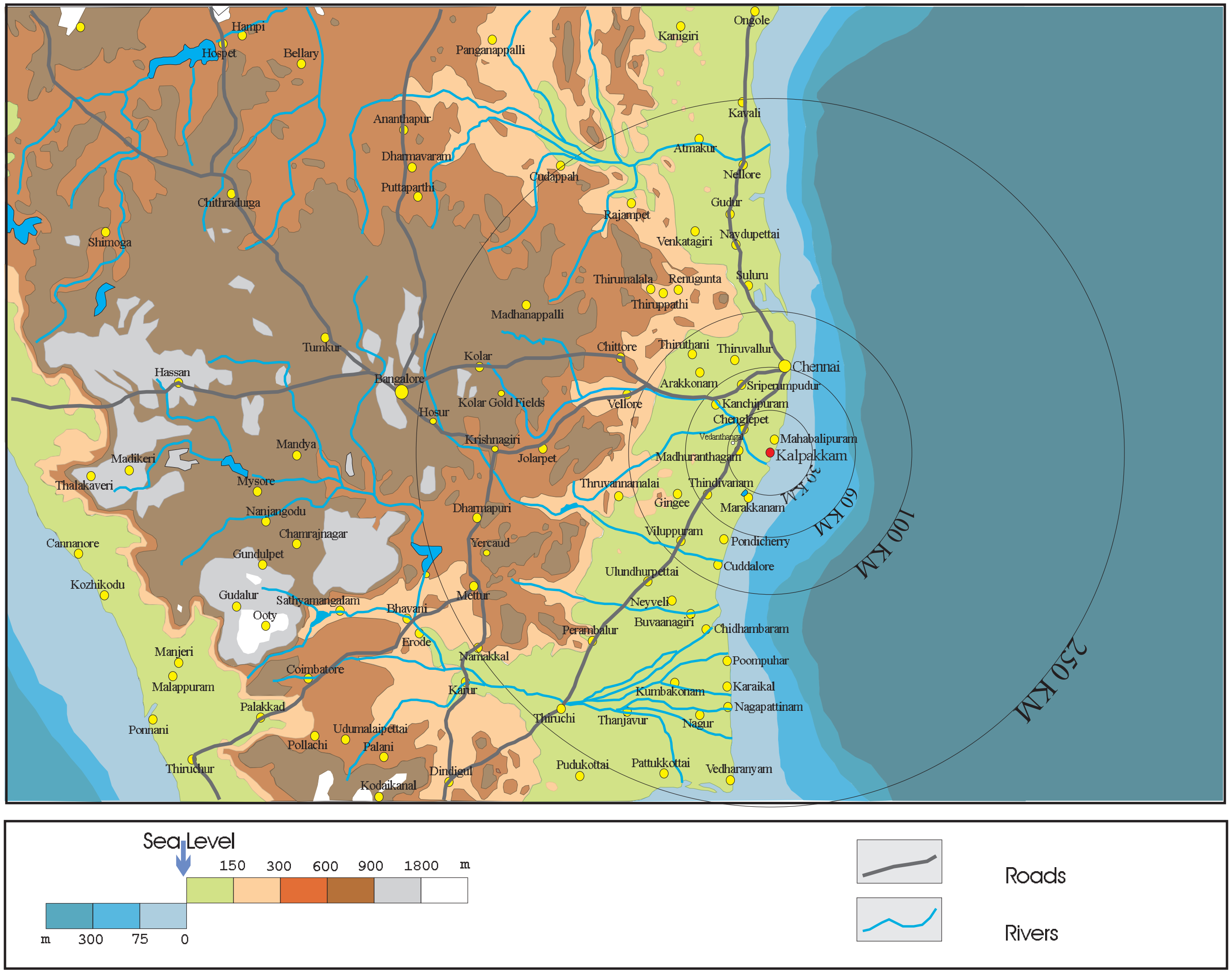
Many scientists at the AEC themselves did come forward to correct the errors that were present in the original draft in the values of Plutonium needed by the PFBR. I am heartened by their acts.

Dr.Dhirendra Sharma sent me his review of the original draft within a few days. I have incorporated many of the suggestions he had given me in this draft. Thank you sir.

The Tamil environmental magazine "Puthiya Kalvi" has brought a special issue on the PFBR after this first report. 'The Hindu' is regularly publishing 'points and counterpoints' on the PFBR for the past four months. Dr.Anil Agarwal of the "Down to Earth" magazine has replied me that he shall be bringing out an article on the PFBR in the next issue. Thanks to all of you for introducing and bringing this topic into the Public Space.

Ramesh.R
Kanuvai,
Coimbatore-108
14-07-2001

Kalpakkam and Regional Topography



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Chapter 1

Kalpakkam's Fast Breeder

Can Tamil Nadu cope with it?

Kalpakkam is gearing up to have another Nuclear Reactor!

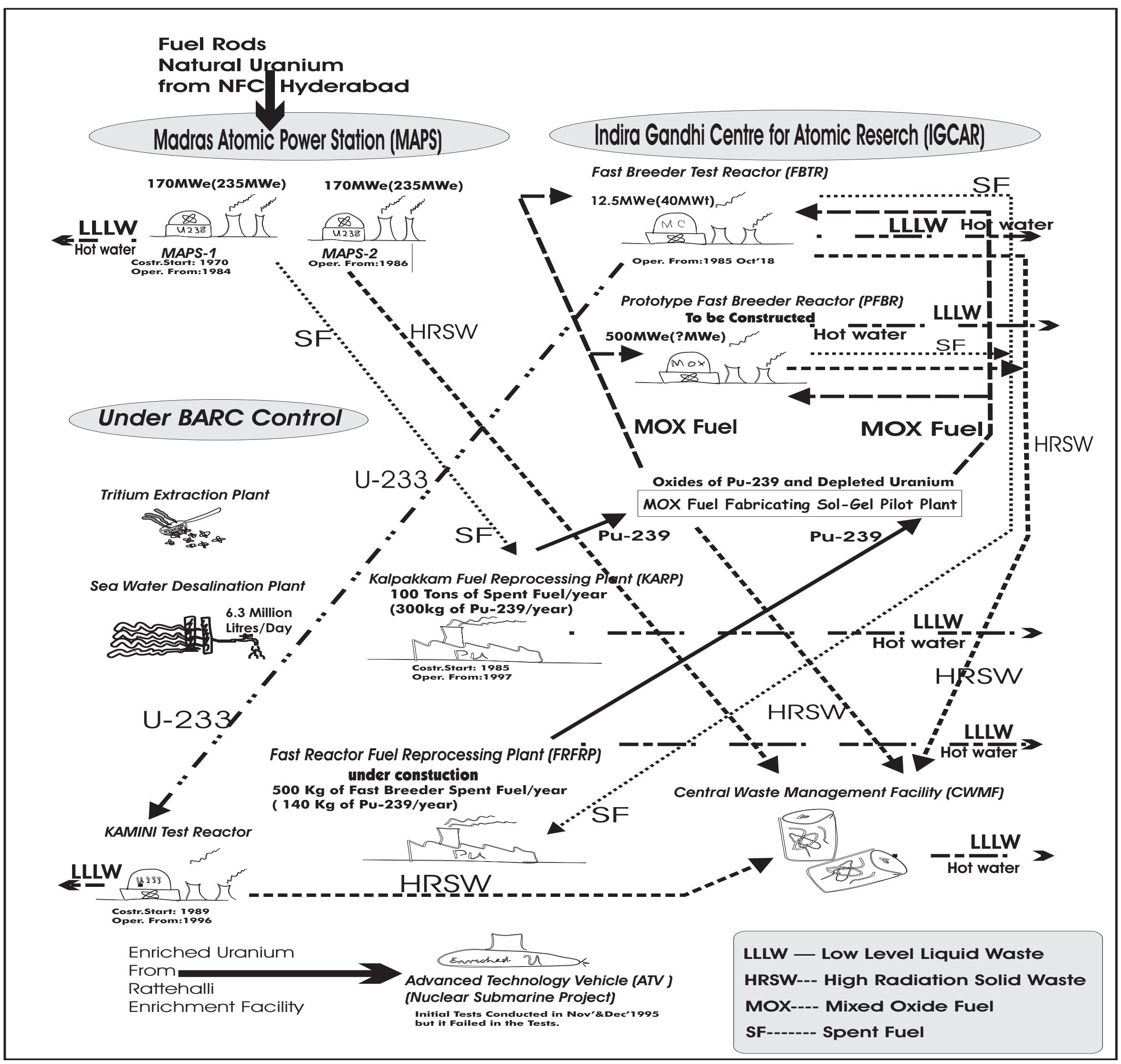
This is a different type of a Reactor altogether; it is a Fast Breeder; the Nuclear establishment has given it the name the "Prototype Fast Breeder Reactor" (PFBR).

Its Design capacity is 500 MWe. This is around 1.5 times larger than the combined total capacity of the 2 MAPS Reactors operating at Kalpakkam.(340MWe).

It's construction is expected to start in December, 2001; if every thing proceeds as planned, then, its construction will get completed in the year 2009.

Whether we, here at Tamil Nadu, should go for this Reactor or not, is the most urgent question that is in front of us today.

KALPAKKAM NUCLEAR COMPLEX



Chapter 2

The Kanchi Public Hearing.

Out of the many firsts that the Kalpakkam Nuclear Complex now has in its kitty, the latest one will be the act of the Public Hearing that will be conducted on the Environmental Impact Assessment (EIA) done on its new Fast Breeder Reactor. Till date no reactor in India has gone through this process. It is the Government of India's "The Environment (Protection) Act,1986", that has made this first possible.

Kalpakkam is the right place to have been chosen for this job. It is located just 6 km south of Mahabalipuram's Rock Cut Temple, the architectural wonder of all times. Constructed during the 8th century by the Pallava King Nandivarman II, it left a big impact on the architectural scenario of the South India and South-East Asia. Kanchipuram, then the Capital of the Pallavas was the hotbed of philosophical debates among Jaina, Buddha and Vedic Religions. It was remembered rightly as the Southern Nalandha for a very long time. It is in this city which was once known worldwide for its intellectual climate, the first ever public hearing on a nuclear reactor of India is going to happen on 27-07-2001 at the District Collectorate building at 11 a.m.

Once constructed, this 500 MWe Prototype Fast Breeder Reactor (PFBR) shall not only become a Technology demonstrator for India among the other countries of the world, but also be an uplifter of the people around, that's what our Kalpakkam nuclear establishment is telling us. Hence it seems to be a wonderful project to dream about!

But there are people who speak against this project. They say that no country in the world, however advanced they are in the nuclear technological front (say, the USA, and France) have been able to handle this Technology without major accidents; their inability to cope with this complicated Technology has forced them, these critics say, not to consider building this type of Reactor anymore in their country, and to close down the already operating reactors as early as possible. Japan, which started taking up this programme with much enthusiasm only 2 decades ago, has burnt its fingers with this Technology now, and is no more in the mood to construct new Fast Breeders, they say. This country, which accumulated Plutonium only for the purpose of using it as the Fuel for its Fast Breeders, has now been forced to use them completely in their Light Water and Heavy Water Nuclear Rectors as it is unable to operate its Fast Breeders any more. Its tragic honeymoon with the Fast Breeders has lasted, like in the case of the USA and France, only for a mere 20 years. This is the view point of the Critics of the Fast Breeder Technology. Their reasoning tells us that any dream to have a Fast Breeder Programme in this country will turnout to be a Nightmare!

We shall analyse the validity of the above statements in the following pages; for this we shall consider the EIA conducted for this Reactor by the Metal Company MECON of Ranchi, and many other materials related to the Fast Breeder Technology around the world as the Source materials of our analysis.

Chapter 3

Fast Breeder Nuclear Reactors

What is Fast Breeding? How does it differ from the Conventional Nuclear Reactor Technology?

It is the method with which you produce MORE Fuel than you actually burn!

In this case, the Fuel is a Mixture of Oxides of Plutonium-239 and Depleted Uranium. It is called in short as the MOX Fuel. (In contrast, our conventional Pressurised Heavy Water Reactors use Natural Uranium as their Fuel). The share of Pu-239 in this MOX Fuel is usually 21-28% . This Fuel when burned (fissioned) in the Reactor Core, leaves behind MORE Plutonium than that was originally present. The MOX Fuel generally gets fully burnt within a time span of 8-10 months; after this period, the reactor is shut down, the spent fuel is removed from the Reactor Core to a storage pond next and then stored under Water for around 3 years so that it can become less radioactive. Soon after this, it would be taken to a Fast Breeder Fuel Reprocessing Plant, where the Plutonium would be separated out; this Plutonium would in turn be used for fabricating the MOX fuel again.

A Fast Breeder uses the Liquid Metal Sodium as its Primary & Secondary Coolant. This metal is chosen for the job (in spite of its inherent nature to catch Fire easily) because of its High Boiling Point. The Conventional PHWR Nuclear Reactors, and the VVER-1000 Reactors that are planned to be constructed at Kudankulam use Heavy Water (D_2O) and Light (Ordinary) Water respectively as their Coolants.

What are the reasons given by the Indian Nuclear Establishment for taking up the Fast Breeder Programme?

The MECON EIA tells us the reasons as to why Our Nuclear Establishment decided to adopt a Fast Breeder Programme. It says:" Uranium Reserves in India are estimated to be around 78,000 tons. If it is used in the Pressurised Heavy Water Reactors (PHWR), it is possible to have an installed capacity of about 10GWe and sustain power generation for 40 years Therefore, it is important to consider reprocessing the Spent Fuel and Recycling unburnt fuel for better utilisation of Nuclear resources. For fuel utilisation to be substantial, it is necessary to have Fast Breeder Reactors....With this, it is possible to go up to a capacity of 350 GWe.... In addition to this, India has about half the world's Thorium reserves (5,18,000 tons). Thorium is not a nuclear fuel by itself but can be converted into U-233, which is a fuel material... Once full capacity is reached with FBRs based on U-Pu cycle, Thorium breeding cycle can be introduced (in them) assuring adequate power generating capacity for a long time." (p-1-3).

Why Kalpakkam was chosen for this project?

Again, the MECON EIA tells us: " A site selection committee (for locating the Fast Breeder Reactor) was constituted by the DAE during 1983 to select suitable sites for nuclear power in the Southern Electricity Region and consider criteria such as site geology, general hydrology, water availability, environmental factors like population density, meteorological factors, seismic condi-

tions, transportation problems etc. One of the sites considered for appraisal was Kalpakkam. Besides meeting the statutory acceptance criteria mentioned in Table 1, Kalpakkam site has several other favorable factors for locating PFBR. Some of the findings of the committee in this regard are summarised below:

1) An Exclusion Zone is already established for the site.

2) Being a Coastal site, adequate water supply for condenser cooling and for dilution of Liquid Effluents is available.

3) Several well-established inter related nuclear facilities required as infrastructure for the construction and the operation of a nuclear power plant already exist in the Kalpakkam complex. Further, there is a strong R&D base to support any developmental activities needed for PFBR.

4) Kalpakkam has a plain topography. Further, the meteorological condition at the site is characterised by short periods of calms and strong wind. These factors are favorable for good dispersion and hence better dilution of gaseous effluents.

Considering all the above features, Kalpakkam was chosen to be the most suited site for setting up PFBR...."

Chapter 4

PFBR and the Regional Environment

In this section, I shall summarise those sections of the Mecon EIA that deal with the routine and Non Routine interactions of the PFBR with the Kalpakkam regional environment.

How will the PFBR interact with the Kalpakkam Regional Environment?

The enormous amount of Heat released and the Radioactivity generated during the course of the Reactor operation, are the two main presumed interactions of the Reactor with the Kalpakkam regional environment; Apart from this, the interactions with this environment of the Other Chemicals used during this process should also be taken into consideration.

I) What will be the Routine Normal Interactions of the PFBR with the Regional Environment?

1) Fuel Replacement Cycle

The Reactor uses Mixed Oxides of Plutonium-239 and Depleted Uranium (here Natural Uranium) as its Fuel. This fuel will be removed once in 8 months (that is after 185 effective full powerdays) and new Fuel will be reloaded. This will be done in a Reactor Shutdown condition. Hence, we can infer (as the MECON EIA does not mention this explicitly) that after an 8 months of functioning the Reactor shuts down for a Routine Refueling operation. For how many months the Reactor will remain shut for this purpose, the MECON EIA does not say.

This Fuel is a part of a system called Core Sub Assembly. The other parts of this Core Sub Assembly are: the Blanket (This is Depleted Uranium Di Oxide usually; But, Thorium will be used as the Blanket once the PFBR achieves its full capacity), Absorber (Enriched Boron Carbide -B4C), and the Shielding Sub Assembly. These Components will be handled along with the Spent Fuel in the Reactor Shutdown condition once in 8 months.

2) The Amount of Plutonium that will be Used as the Reactor Fuel

The amount of Plutonium that will be used to make up this Fuel Core is 2000 Kg(2Tons). (The total amount of Fuel that goes to make the Fuel Sub Assembly (that is including Uranium Di Oxide) will be around 10 Tons.) (p-2-7).Once in every 8 months, $1/3^{rd}$ of this 2 Tons of Plutonium will be loaded into the Core (that is 0.67 Tons) for another 45 years (Reactor Lifetime). (p-2-7). Thus if the reactor remains shut for roughly 2 months a year, for the next 45 years, the amount of Plutonium that will be required will be around 37,500 Kgs (37.5 Tons).

3) The Amount of PHWR Fuel that should be Reprocessed for getting this amount of Plutonium

It is normally presumed, that the Reprocessing of 1 Ton of PHWR (or CANDU Reactor) Spent

Fuel will usually yield 10 kgs of Plutonium internationally. Here in India, it is said that the yield is only around 3kgs/Ton of reprocessed spent fuel. The annual Pu requirement of the PFBR is 1000 kgs. But the combined reprocessing capacity of the Reprocessing Facilities at Kalpakkam [Kalpakkam Fuel Reprocessing Plant-KARP -(Capacity-100 Tons/ Year, that is 300 kg of Pu/Year), and the reprocessing plant currently under construction namely, Fast Reactor Fuel Reprocessing Plant -FRFRP- (with a capacity to Reprocess 500 Kgs of Fast Reactor Spent Fuel/Year ~ 140kg of Plutonium] will be capable of producing only around 440 kgs of Plutonium annually. Where will the remaining 560kgs of Pu come from? This might be handled in the following way. As the PFBR is supposed to be commissioned only around 2010, the Kalpakkam Reprocessing facilities would have have repocessed enough Plutonium before that. The FRFRP will be getting the Fast Breeder Spent Fuel only after the PFBR is commissioned in 2010. By 2010, the contribution of Pu from KARP (from 2001 to 2010) would have been 3000kgs.So PFBR shall be starting with a surplus of 1000 kgs. *For all this the Kalpakkam Reprocessing Plants would have reprocessed around 1000 Tons of MAPS fuel. What shall be the environmental impact of Reprocessing such a large quantity of Spent Fuel? The MECON EIA does not raise this question at all.*

4) Using the Sea Water as the Condenser Cooling Liquid

A) Heat Disposal into the Sea

Sea Water will be used as the Condenser cooling liquid. The amount of Sea Water that will be sucked by this Condenser Cooling System will be around 76.68 Lakh Liters/Hour or 1840.32 Lakh Liters/Day. This will be allowed to circulate around the Steam Generator Pipelines in order to absorb their heat and condense the steam of the steam generator into water; this condensed water is pumped again to circulate around the Secondary Sodium Coolant loop in order to absorb its heat and thus get converted into Steam once again. The heated condenser sea water is let into the Sea again and this will heat the Sea around. Whenever the Reactor is shutdown or restarted there will be "Shock Discharges of Hot Water" (p-5-10), which might induce a great stress on the local marine organisms.

B) Addition of Chlorine as a Biocide to the Condenser Sea Water

Chlorine will be added at the intake point to act as an antifouling agent. (The amount of Chlorine that will be added or the amount of Free Chlorine that will be discharged into the Sea is not given in the MECON EIA. It merely says, "the experience at MAPS shows that the levels encountered are typically about 20% of the norms.... Infrequently, shock doses of Chlorine will have to be added at the intakes to get rid of fouling organisms. So the final effluent may slightly have high content of residual Chlorine which may cause some damaging effect near inlet of the channel which will soon disappear near the outfall of the channel before merging into the sea. However, restoration will start soon after the shock dosing is discontinued.")

C) Disposal of Low Level Liquid Radioactive Wastes into the Sea through the Condenser Sea Water

There are two sources from which this Low Level Liquid Radioactive Waste (also called Category I Waste) will be generated. One of the sources will be the wastes that will be generated from Wash Basins, Change Room Showers located in active areas, etc. These will be collected in the Storage Tanks located in the RAD Waste Building (RWB), and then pumped into the condenser cooling sea water.It will be 30,000 Liters/Day. (p-5-21). Apart from this, another 64,000 Liters of Category I Liquid Waste will also be generated from the Lab washes of the plant (p-5-15); as in the previous case this will also be mixed with the condenser sea water to be let into the Sea. Thus the total amount of Category I Waste that will be let into the Sea by the Condenser water will be 94,000

Liters/Day. What will be the radio active elements present in this Category I waste , the MECON EIA doesn't mention.

D) The effect on the local marine organisms by the large scale pumping of the Sea Water

The pumping of 1840.32 Lakh Liters of Sea Water/Day will draw an enormous amount of Marine Organisms into the Condenser channel of the PFBR reactor. Very small aquatic organisms like Phytoplankton, Zooplankton, Planktonic larval stages of Benthic organisms, Fish Eggs, and Larvae will be sucked into this flow, exposed to heat, mechanical, pressure, and chemical (Chlorine) Stress (this process is called Entrainment) before getting released into the Sea. (p-5-9). These organisms are sure to get decimated during this process because the Temperature they would be put under at the point of contact of the condenser channel and the Steam Generator Loop will be 339.85^{0}C. (as given in the Fig.2.01, p-2-4). These organisms are incapable of resisting even a 5^{0} C temperature rise; here there's an increase of 308^{0}C, so there will be no chance left for these organisms to escape death. The north bound long-shore currents of the SW Monsoon, and the south bound NE Monsoon are bound to bring in fresh stocks of these organisms, which in turn will get decimated by this Condenser Suction system. But, the question here is what will be the total capacity of this system to alter the regional marine bio- resource?

5) Exporting the Radioactive Wastes to the Centralised Waste Management Facility (CWMF) and the Waste Immobilistion Plant

Apart from the above mentioned Low Level Liquid Wastes, the PFBR will be producing Intermediate and High Level Liquid Wastes, and Solid Wastes. It will export these wastes to the CWMF by two means. A part of the Liquid radwastes will be pumped directly to the CWMF. The remaining part and the Solid radwastes will be collected and transported in Containers to the same facility.

A) Intermediate and High Level Liquid Wastes

These radwastes are classified into 3 categories. Category II liquid wastes will be collected in 2 storage tanks each of 30,000 liters capacity present in the Radioactive Waste Building (RWB) and then pumped to the CWMF. At the CWMF it gets treated, and the Liquid part is sent into the Sea. The solid sludge left out is treated, concreted and stored. The volume of the Category II waste that will be generated will be around 30,000 Liters/ Day.

Category III wastes will be generated in the Spent Fuel Storage Bay (SFSB) area when the Spent Fuel is washed of the Sodium sticking on to it is washed in the Fuel Transfer Cell; also these wastes are generated in the Decontamination area of the RWB. They will be collected in the Storage Tanks of the RWB, which will then be transferred to containers that will be shipped to the CWMF. The transportation and conditioning of these wastes will be supervised by Health Physicists. At the CWMF, these wastes are steam evaporated, the condensate of this process is treated and discharged into the Sea. The concentrate of this process is concreted and stored. The fuel handling will generate around 21,000 Liters of waste, and the decontamination act that will follow will generate around 2.8 Lakh liters of category III wastes.

The Category IV High level waste is generated sometimes, when the Clad Tubes of the Spent Fuel Sub Assemblies rupture while being washed chemically to remove the Sodium sticking on to them; It is collected in the Storage Tanks present in the Shielded Areas of the RWB, later transferred to shielded containers which will be mounted on Tankers and shifted to the Waste Immobilisation Plant and the CWMF. There it will be Conditioned, Fixed and Stored. The amount of Category IV waste that will be generated will be around 10,000 Liters.

These liquid wastes will be containing ^{137}Cs, and ^{90}Sr predominantly.

B) Solid Wastes will be stored in RCC Trenches

Solid Wastes can be classified into Combustible and Non Combustible Wastes. The Non Combustible Wastes can further be classified into Compressible and Non Compressible Wastes. These wastes are again classified into 4 Categories. The Category I & II Wastes will be packed in double PVC bags, sealed and tagged. The Category III & IV wastes will be packed in Polythene or Metallic containers and placed in shielded flasks. They will be stored temporarily in the RWB itself. It has the space to store one month waste. They will be transported to the CWMF under the supervision of the Station Health Physicist.

At the CWMF, the combustible solid waste (e.g.. Clothing, Rags) will be incinerated and the radioactive ash will be collected in drums, immobilised in cement and will be placed in RCC Trenches. The Compressible Waste will be baled on a hydraulic press and will be sent either for incineration or for disposal in RCC trenches. The Non-Combustible, Non-Compressible waste will be disposed off in RCC trenches or Tile-Holes depending upon their activity level. An area of 1 Hectare will be required for these RCC trenches or Tile Holes to accommodate all the wastes generated during the plant life of 45 years. (p-7-14).

The probable radionuclides that will be present in the solid wastes will be: ^{3}H, ^{22}Na, ^{54}Mn, ^{60}Co, ^{134}Cs, ^{137}Cs. (p-5-20).

C) Transporting the Spent Fuel for Reprocessing

The spent fuel and the irradiated Thorium blanket will be reprocessed at the Reprocessing facilities of Kalpakkam. The spent MOX fuel will be stored in the Spent fuel Storage Bay present in the reactor containment building itself. They will remain there under water till they are ready for reprocessing (? for 3 years) . After this period, they will be transported to the Reprocessing Plants in Special Flasks/Casks of Type (B), conforming to the design criteria given in AERB Safety Code AERB/SC/TR-1(1986)...The radiation level at the external surface of the package shall not exceed 10mSv/Hour. Temperature at its external surface shall not exceed $85^{0}C$ in the shade for an ambient temperature of $38^{0}C$. (p-5-32). Prior to this transport, necessary advise from Health Physics Unit shall be sought and all necessary radiation protection procedures will be followed so that the radiation dose to the personnel engaged in the operations are controlled. (p-5-32).

5) Release of Gaseous Wastes

The major Gaseous Radionuclides that will be released from the PFBR through the Stack are : ^{41}Ar, ^{3}H, ^{87}Kr, ^{88}Kr, ^{133}Xe, ^{135}Xe. (Unlike the PHWRs) Isotopes of Iodine and Cesium are usually not released from the PFBRs. This is because the Sodium coolant of the PFBR forms Sodium Iodide with the Iodine released. The quantity of Noble gases that will be released annually will be around 17,000 TBq; out of this, ^{133}Xe and ^{135}Xe constitute nearly 98.6%.

PFBR will be permitted to operate even under the conditions of Failed Fuel elements (at any time NOT MORE THAN 4 PINS). (The total number of Fuel Pins in the Core will be 181 (fuel sub assemblies) X 217 (Fuel Pins)= 39,277 Fuel Pins). (p-5-24).

There are Two types of Releases and Two categories of Gaseous Wastes. The two types of releases are a) Planned and b) Unplanned. The two categories of Gaseous wastes are a) Category I and b) Category II Wastes.

These releases will be made after passing them through a Charcoal based Cover Gas System (CGPS). The gas that leaks into the Reactor Containment Building will be scavenged by the plant ventilation system. The unplanned releases (blow-down from relief job) will be very small in quantity and they will be collected and stored in a surge tank, monitored and then released through the 100 m tall stack.

6) The need for Fresh Water

The average Daily demand of Fresh Water is about 15.31 Lakh Liters/Day (1,531 m^3/Day). The breakup of this is as follows: Demineralization Plant-7.6 Lakh Liters/Day, Domestic (potable) Water - 1.44 Lakh Liters/Day, Air Washer Units - 4.08 Lakh Liters/Day, Pressure Filter back washing -.75 Lakh Liters/Day, Miscellaneous Uses -1.44 Lakh Liters/Day.

The source of this water Water will be from an intake well in the Palar River Bed. This intake well will be present near Panankattucheri in the Lathur Block of the Kanchipuram District. It is around 16 km South West of the PFBR site. Already there is a similar intake well for the MAPS plants of Kalpakkam from the same area. The present pipelines of 600mm dia. will run parallel to the MAPS pipeline.

The headworks will be operated by the TamilNadu Ground water Board.

Apart from this an open Reservoir of 190 Lakh Liters (19,000 m^3) capacity will be constructed at the PFBR site to tide over the interruptions in the water supply from the head works. This will meet the needs of the plant for about 7 effective full power days (EFPD).

An underground storage tank of 40 Lakh Liters (4,000 m^3) capacity will be built, out of which 23 Lakh Liters will be dedicated to fire fighting. This tank will receive its water from the reservoir. Water is pumped from here to the DM plant, Domestic Water System, the Air Washer Units and the Pressure Filters.

The DM Plant provides water for the Steam-Water System, Service Water System, Biological cooling system, Chilled water system, decontamination facility, Spent Fuel Cooling, Package Boiler, Condensate Polishing unit (CPU) regeneration.

The DM plant has a storage capacity for 24 hours makeup and individual closed loop system has an expansion tank with storage of 8 hours makeup. So interruptions in the DM plant operation do not affect safety.

The Spent Fuel cooling system tolerates loss of cooling for about 112 Hours (4.7 days) without any adverse consequences. The Roof slab has a large thermal capacity and so can withstand loss of cooling for about 8 Hours without causing any deflection. For the Diesel Generator coolers, a provision is made to supply Fire Water in case of Non-availability of the Service Water (DM Water) for short periods. In the case of the Biological cooling system heat exchanger, an overhead tank is envisaged to supply cooling water on once through basis in case of non-availability of service water, thus ensuring cooling of shield concrete.

Firewater system will be used to suppress fires in safety related areas which do not house Sodium equipment/piping. It has been designed to take care of fire fighting needs based on the maximum expected flow rate for a duration of 2 Hours. As said above, this will have 23 Lakh liters of water at its disposal.

The Chilled water for air-conditioning will be provided by the DM Water system and this will be used by the Air Conditioning System of the plant for maintaining the various parts of the plant like the Reactor Containment Building at around 23.85^{0}C (297 K).

7) Use of Nitrogen Gas and Argon Gas

Nitrogen will provide an inert atmosphere in components and cells and mitigate the consequences of any Sodium Leak and Fire.

Since Sodium Leak and Fire is one of the prominent problems of a Fast Breeder Reactor, the supply of Nitrogen gas is of greatest importance in a Fast Breeder setting.

This Nitrogen is produced by a PSA type plant of capacity 30 Nm^3/Hour at 0.5 MPa and stored in a horton space of 1200 Nm^3 at 1.5 MPa after booster compressing.

The Steam Generator Tubes will be filled with Nitrogen whenever Steam/Water is drained from it, to avoid the corrosion of these tubes.

Argon Gas will be used as a Cover gas over Sodium surface in all vessels and also for flushing

and providing inert atmosphere in various fuel handling facilities. It will be supplied at 0.8 MPa pressure from 5 cylinder banks of 30 cylinders each.

8) Reprocessing and MOX Fuel Fabrication for the PFBR Plant

In reprocessing, spent fuel rods are broken open and the outer cladding is dissolved in nitric acid. The plutonium is then separated out. The remaining highly radioactive debris is stored as liquid in large carbon or stainless steel drums, awaiting some kind of solidification and storage in the Central Waste Management Facility. Waste of lower radioactivity is (as in Windscale (Sellafield) in England) piped out to sea. The spent nuclear fuel rods and liquid reprocessing waste are called `high level radioactive waste'. They will be stored in the CWMF for years till a permanent Waste Repository is found for India for disposing such Wastes for hundreds and thousands of years.

Radioactive iodine is routinely released in large quantities by nuclear reprocessing plants and this amount is much larger than the routine discharges of radioactive Iodine from the conventional Thermal nuclear power plants. (No Immediate Danger, Prognosis for a Radioactive Earth, by Dr. Rosalie Bertell, The Book Publishing Company -- Summertown, Tennessee).

In addition to the activities of the Reprocessing plants, the routine functioning of the MOX Fuel Fabrication plants should also be taken into consideration, as a routine interaction of the PFBR with the Kalpakkam environment.

II) What will be the Non-Routine Emergency Interactions of the PFBR with the Regional Environment?

1) Addition of Shock Doses of Chlorine at the Seawater inlet of the Condenser Cooling System

This act as we have seen above will have a great detrimental impact on the marine life of the region.

2) Discharge of Shock Doses of Hot Water into the sea, when the Reactor is Shutdown and Restarted

This will reduce the populations of Protozoans of the region. Similar effect is likely due to the seasonal changes in the thermal plume. (p-5-13, Mecon EIA)

3) Leaching of the Solid Radioactive waste containers stored at the Central Waste Management Facility

This can occur sometimes. The leached radioactive elements will come into contact with the ground water. The design of the storage is such that the possibility of leakage of radioactivity is extremely unlikely. Should such an incident occur, the ground water contour in the locality is such, the contaminated ground water flows only towards the sea resulting in no impact on the public. (Mecon EIA, p-5-21)

4) Start-up of the Passive Direct Reactor Cooling System

In the event of a Loss of Off-Site Power during the Reactor Shutdown when the Decay Heat (heat generation in the core even when the reactor has been shutdown; this is due to the continuing radioactive decay of the fission products) is being removed, a safety system called the Passive Direct Reactor Cooling System goes into operation.

Generally, the decay heat will be removed by the normal heat transport path through the Steam Generators; but in the case of Loss of Off-site power or Non-Availability of Secondary or the Seawater Circuit, the decay heat will be removed via a Passive Direct Reactor Cooling System.

It consists of Four independent circuits of 6MWt capacity; each having a Sodium to Sodium

Heat Exchanger dipped in the reactor hot pool, and a Sodium to Air Heat exchanger. (Mecon EIA p-2-28)

During this process, the Reactor will be releasing extensive amounts of heat into the local atmosphere; also it will be releasing enormous amount of radioactive materials into the atmosphere. The EIA is silent on this issue. It does not state the nature of Releases from the reactor during this process.

5) Activation of the Core Catcher in the event of a Core Meltdown

The Core Catcher is the safety system built into the reactor that shall play a major role in the event of a Core Meltdown.

This will collect the molten fuel, disperse it suitably and ensure long term cooling in the most unlikely event of a Core Meltdown. (Mecon EIA, p-2-28)

This event will generate a very large amount of highly radioactive Liquid and Solid Wastes. This highly radioactive Liquid Waste will most likely be dumped directly into the sea. The EIA is extremely Silent on this issue.

6) Dependance on Off-Site Power

The PFBR will be connected to the TamilNadu/Southern Regional Grid to receive and evacuate power. The net power output from the PFBR to the Grid will be 470 MWe, the balance 30 MWe being the Station requirements. (Mecon EIA,p-2-22)

Sometimes when the on site power is unavailable (say during the routine and emergency reactor shutdowns) the station will have to depend on the TamilNadu/Southern Grid for its maintenance. If this will occur during Summer months when the demand is at its peak, then this will have a major impact on the industrial production of the area.

Chapter 5

Data and Claims

Now we shall move on to analyse the Claim made by the MECON EIA , that the operation of the PFBR will NOT be detrimental to the Kalpakkam regional environment. This we shall accomplish in two ways. First, we shall try to de construct the nature of evidences given by the MECON environmental scientists in support of their claim. Secondly, we shall try to posit the historical events of malfunctioning of the Fast Breeder Reactors across the world against the routine and non-routine interactions of this Fast Reactor with the Kalpakkam environment around. This will tell us very clearly about how exactly this reactor is going to operate in the Kalpakkam environment once it is built.

The Nature of Evidences given by the MECON EIA

The Data used

This Report of the MECON EIA is based three groups of data.

The first group of data is not site specific but is about the region. This is pertaining to the nature of the Coast, seismic potential and the tectonics of the region, wave & ocean current data for the region etc.

The second group of data comes from the studies conducted on the site by other institutions. Thus, the EIA has considered the data that had been acquired by the Meteorological station present at the site for the period between 1970 to 1995. The fish landing data for the region for the period between 1993-1998 given by the Central Marine & Fisheries Research Institute (CMFRI), Cochin and the data on the radiation present in the region that had been collected by the Environmental Survey Laboratory at Kalpakkam are also considered as the EIA's inputs. It has also taken as its input the geological data generated from 21 boreholes drilled at the PFBR site.

The third group of data comes from the study the MECON team has conducted at the Kalpakkam site for 3 months from August to October 1999. It has stated in the present report that the data generation would continue up to July, 2000 and another Final EIA report shall be published based on this one full year data.

The Arguments used in support of the PFBR

There are Five levels of arguments that are put forward to justify the construction of this reactor.

1) The first argument compares the abundance of Thorium present in India to the scarcity that the country faces in the other Sources of Energy. It talks about how the wind and solar power technologies are unreliable for bulk power production. It then puts forward a Three Stage Long-term Energy Policy based solely on the use of Nuclear Energy. It is here that it stresses the necessity for developing Fast Breeder Technology. A Reactor using such a Technology is the proposed PFBR, it tells us. It later compares the efficiency of the Fast Breeders in utilising the natural resources to that of the conventional nuclear rectors.

2) Once the necessity to build this type of Reactor in India is established, the next level of argument is about the Site where this reactor would be built. It states that the Site for the reactor meets the requirements demanded by the Atomic Energy Regulatory Board (AERB). Hence, one need not worry about whether the reactor was built at the right site at all. It is after putting forward this argument, that the other sets of arguments on the reactor follow. If the site happens not to meet these requirements of the AERB, there wont be any necessity to talk further about the construction of the reactor at all.

3) The next level of argument is on the inherent safety aspects of the Reactor. It enumerates the very many aspects that are present in this reactor which will make this reactor fail safe.

4) Once this is established, the next step will be to state that the interaction between the Reactor and the Environment around will be beneficial and not hazardous to the living beings around.

5) After this step will be the step of posing a doubt on the safety profile of the reactor. It goes on to consider the various aspects of the reactor that can go wrong; it proposes how the hazardous effects of those failures could be overcome. It also considers the measures that should be taken at the site and in the region around in case of an accident; this final step of argument states that such accidents will occur only very rarely but still no chance is being given for such events to happen.

Once these sets of arguments are completed, anyone who goes through them is bound to give his consent for the project.

Chapter 6

Nature of the Data Used and the Structure of the Arguments

1) The First Argument:

The EIA just states the meagre amount of Uranium reserves present in the country and then goes on to compare the number of years for which this could be burnt in the conventional pressurised heavy water reactors and in the Fast Breeders. It thus establishes the advantages of the Fast Breeder Technology. It then goes on to argue about the advantages of using Thorium as a fuel. It then compares the number of years that this could be used as an Energy source to the number of years that the Coal, Oil, Natural Gas reserves of the country could be used. It states "...non conventional energy sources such as wind and tidal energy can at most meet a small quantum of our demands." (p,1-2).

What is the actual meaning of this argument?

~The above argument considers the Issue of Power as a Supply and Demand problem. How you meet this demand will never be a problem as long as you meet it ; this is what the above statement wishes to convey.

~This argument inherently considers all the technologies for the production of Electricity as equally safe. Chernobyl will, according to this argument, be as safe as the Wind Mills of Aralvaimozhi of TamilNadu.

~It applies the aspect of efficiency for the production of Power only to the Other Power production technologies like the Wind and the Solar power. It does not apply the same aspect to itself. In fact, among all the energy producing techologies, it is the Nuclear Power Technology which has performed the least in India. When we compare the budgetary support that this Technology has received during the past four decades with that of the Wind and Solar Power we are forced to see the truth that for the least budgetary support they have received, the wind and solar power have performed very well; but the performance of the nuclear power has been the worst in spite of the fact it has received a great financial support from the government.

To meet the future energy demands of India we should certainly have a long term Energy Policy. The basic aim of that policy should be to promote Energy Producing Technologies that are Sustainable and Safe. Utilisation of Nuclear Energy is neither safe nor sustainable. The mere presence of half the World's reserves of Thorium in India will not make it a sustainable option. The technology to achieve that goal is the most unpredictable and the most dangerous option present in front of us. That is what the World's history of Nuclear Energy is telling us; by reducing all that to a Supply and Demand problem the MECON EIA is attempting Trickery and not Science.

2) The Second Argument:

"The Site chosen for building the PFBR meets all the siting criteria of the AERB."

In this the EIA mentions 8 siting criteriae of the AERB (March, 1990) under the following headlines. They are: i) Seismicity, ii) Distance from capable fault, iii) Distance from small airfields, iv) Distance from major airports, v) Distance from military airfields, vi) Grade elevation above

Astronomical East coast tide, vii) Population, and viii) Distance from historical monuments of tourist interest.

Of these we shall analyse the facts and arguments used by the MECON EIA for the criteriae numbered i, ii, vi and vii. (in Table 2-01, p,2-2)

We shall consider the Criteriae numbered i and ii together, as they are closely related to each other.

a) Seismic Potential of the Kalpakkam Site

According to the AERB's Guidelines for the Siting of Nuclear Power Plants vide safety code AERB/SC/S March' 1990:

i) Any site situated in Seismic Zones beyond Zone IV (IS-1893) shall be rejected. Kalpakkam is situated in the Seismic Zone II; and so shall be permitted to build a Nuclear Reactor.

ii) Any site having a capable Fault within 5 kms., shall be rejected. Kalpakkam has a capable Fault at a distance of 12 kms. So, it can have a nuclear reactor.

"Experts from the Geological Survey of India and various other organisations have identified the faults and other lineaments covering TamilNadu and Andhra Pradesh encompassing different offshore seismo-tectonic conditions. A detailed evaluation of the Kalpakkam site was conducted by the Atomic Minerals Division with reference to PFBR siting. The Gauribidanur Array (GBA) data and the World Meteorological Department (WMD) data were used to assess the seismicity associated with various faults. Based on the study, a magnitude of 6 R scale is taken as safe shut-down earthquake for design." (p,4-2, Mecon EIA)

What do the experts in Earthquake Engineering have to say on this?

The seismic hazard zonation maps 'are only a guide and, for any important construction (like Dams, Nuclear Power Stations), detailed study of the site and its surroundings is essential for a more precise estimate of seismic hazard.' (Jai Krishna, Seismic Zoning Maps of India, in Current Science, Vol.62,Nos.1&2, 25 January 1992).

So, a detailed study of the site and its surroundings is what is essential for a more precise estimation of its seismic hazard. The EIA states that the Atomic Minerals Division has conducted a detailed evaluation of the Kalpakkam site with reference to the PFBR siting. What is this detailed evaluation it does not enumerate. What are the studies that the Atomic Minerals Division has made with respect to the site, it does not mention. It also does not state, whether such a study was published in any reputed science journal so that the quality of its study could be evaluated by the independent experts in this field. Are these actions not mandatory for any large project that is perceived to be dangerous by a section of the Society? Are these actions not mandatory for any project that says that it is basing itself on very strong scientific foundations? Shouldn't the Mecon EIA which is supposed to be a scientific endeavour, cite references to at least the more important statements that it makes in its report?

As the EIA doesn't mention much about the fault line concerned, we ourselves shall try to find more about this.

The Eastern Margin Fault line

There is a Fault line running at around a distance of 20 kilometers west of Kalpakkam. This has a NE-SW direction. It is called the Eastern Margin Fault line. It runs between Chennai and Cape Comerin; It represents the boundary line between the Sedimentary formation on the east and the

gneissic crystalline rocks of the upland in the west. (Mishra D.C., et.al., in Memoir Geol. Soc.of India, No.25, p-204). Palar River takes 90^0 turn in the Chenglepet area because of this lineament. (Ramasamy S.M., et.al., Remote sensing and Pleistocene tectonics of Indian Peninsula, in Int.J.Remote Sensing ,1995, vol.16,no13.p-2784). Vemban et al. (Major faults/dislocations/lineaments of Tamilnadu. Geological Survey of India. 1977, Miscellaneous Publication. 31, 53-56) observed that out of 38 earthquakes between 1823 and 1968 AD in various parts of TamilNadu, 28 were near the NE-SW trending lineaments and six along the crystalline-sedimentary boundary of the East coast of TamilNadu. A series of earth tremors have occurred along this lineament (Chennai, Thambaram, Mamandoor, Ariyalur) suggests its Pleistocene pulsation. (Ramasamy S.M., et al. ibid., p-2384). To be exact, Chennai has had 2 earthquakes one measuring 4.30 R, the other 3.0 R in the years 1816 and 1892. A place between Viluppuram and Pondicherry suffered an earthquake in the year 1819 and the magnitude was 4.3 R. (USGS, National Earthquake Information Centre's database).

These studies tell us that the area has had earthquakes in the past. The maximum magnitude of the earthquakes of this area was, however only 4.3R. This means that this area has normally experienced earth quakes that a Seismic Hazard Zone I is supposed to experience.

But just because a place has had an earthquake of a lower magnitude, one can never say with certainty that this site will not experience earthquakes of larger magnitudes in the future. (the recent examples being the Lattur-Killari Earthquake of 1993 and the Jabalpur Earthquake of 1997). So, we should make doubly sure, that such an event of a higher scale will not occur at least in the places in which we shall be having our Dams and Earthquakes. This will be possible, only after a detailed Geological, Geophysical and Seismological study of the area.

The EIA states that the GBA and WMD data were used to assess the seismicity associated with various faults. Based on the study, it further states that, a magnitude of 6R scale is taken as safe shut-down earthquake for design.

Here too the EIA's statement doesn't mention anything about the nature of the data from the GBA and the WMD; most probably, this is data concerning the frequency, intensity/magnitude of the earthquakes that have occurred along the various fault lines; now the question is, whether one can come to a conclusion that this will be the maximum magnitude of the earthquake that this place will experience just by using the data on the frequency, magnitude/intensity of the past earthquakes that this area has experienced?

A study by J.Paul et al tells us: "...the recent earthquakes (of the peninsular India) do not represent the recurrence of earthquakes that may have occurred since the development of script. That is, a Historical search for identical seismic predecessors to ongoing seismicity is likely to be fruitless. The seismic hazard surrounding recent events is likely to be now reduced compared to areas that have not experienced recent earthquakes in South India." (Paul J et al., Microstrain stability of Peninsular India 1864-1994, in Proc.Indian Acad.Sci. (Earth Planet Sci) Vol. 104, No.1, March 1995 p-145).

This study thus tells us that we can not come to any conclusion on the seismic potential of an area that is located in the Indian Peninsular Shield just with the help of the data on the frequency and intensity of the earthquakes that have occurred in the past in that area.

So what should we do?

The only choice left out for us is to go in for a thorough seismo-tectonic, geophysical study of

the area as a whole. This is exactly what the Department of Energy (DoE) of the USA is also suggesting us.

The DoE of the USA gives clear-cut guidelines for conducting such a study.

The recommendations it has put forward with respect to this in the year 1992 are:

“ ~ Facilities or sites with hazardous materials shall have instrumentation or other means to detect and record the occurrence and severity of seismic events.

~ The amount and style of deformation and the likelihood of future displacement shall also be characterized for any Quaternary (approximately last 2 million years) faults in close proximity to the site (within about 8 km or 5 miles).

For investigations of sites containing facilities with SSCs in Performance Category 4 such as nuclear reactor safety, U.S. NRC Regulatory Guide DG-1015 (USNRC, 1992a) provides guidance for identification of the regions to be investigated:

1) Regional investigations using literature reviews and geological reconnaissance should generally be conducted for a radius of 320 km (200 miles) from the site, unless clearly justified.

2) Geological, seismological, and geophysical investigations should be carried out for a radius of 40 km (25 miles) from the site to identify and characterize the seismic and surface deformation potential of seismic sources, or to demonstrate that such structures are not present.

3) Detailed geological, geophysical, seismological, and geo technical (GGSG) investigations should be conducted for a radius of 8 km (5 miles) from the site to determine the potential for surface tectonic and non-tectonic deformations in the site vicinity.

4) The area of detailed GGSG investigations may be larger than a 5-mile radius in regions of late Quaternary earth movements or historical seismic activities, or where a site is located near a fault zone, or complex geology.

It is very disturbing to know that Kalpakkam despite having 2 nuclear reactors, 1 Reprocessing Plant and a waste management facility for a couple of years, is yet to have instrumentation or other means to detect and record the occurrence and severity of seismic events in the region around.

The studies related to Seismology like the Gravitation (Bouguer anomaly) Study is available for the whole of TamilNadu in a general level (Krishna Brahmam.N., in Memoir Geol.Soc.India, No.25, p.167). We do not know whether a detailed Gravitational study has been attempted for the Kalpakkam Region (such a study has not been published in the professional Geology or Science journals, yet.). Probably, it is this study that the Atomic Minerals Division might have conducted. Apart from this other studies like, Aeromagnetic survey of the region, Geodetic Positioning Survey, Deep Seismic Sounding (DSS) study, we are sure, are nonexistent for this region. The Geological Survey of India has conducted an Aeromagnetic survey (in 1982) only for the places at and below the 12^0 N Latitude of South India. Kalpakkam is located at $12^0$32’N.

Hence, we are unable to accept the statement that the Kalpakkam site is in a Seismologically stable location. The statement is not made on the basis of scientific facts. The DAE should now be forced by the Central and the State Pollution Control Boards and the AERB, to take the decision of postponing the construction of this PFBR Reactor till the above mentioned series of studies are conducted to prove the seismological stability of the area.

b) Grade Elevation above Astronomical East coast tide and the type of the Coast

“The AERB will reject any site whose gradation above Astronomical east coast tide is less than

4 Meters. " (p,2-2, EIA). "The proposed plant site is around 3 to 6 meters above mean sea level. In order to qualify the site for safe ground elevation from coastal flooding, the ground level has to be raised to around 6.9 meters above mean sea level. Approximately 0.8 million m^3 of fill materials will be required. The same will be obtained from nearby interior localities." (p,5-3, EIA).

"The Kalpakkam site falls at the depositional environment caused by the floods and coastal processes. There are sporadic and rare occurrences of sea erosion at Oyyalikuppam and the CISF barracks area. This could be due to development of point bars at Palar river mouth aided by sediment deposition. The shore line is relatively stable along the Kalpakkam coast, and remote sensing studies and coastal geomorphological studies indicate a prograding coast for Tamil Nadu except at a few stretches like Mahabalipuram area and Royapuram area at Chennai." (p,4-4,EIA).

The above two topics are interconnected and hence we decided to deal them together.

The question of the type of the coast - whether it is getting uplifted (prograding) from the sea, or whether it is going down into the Sea (Erosional)- is probably the first issue to consider when analysing the Grade elevation above Astronomical east coast tide. The plan to deal with a coastal site located at say 5 meters above the mean sea level in a Prograding type of coast cannot be the same as that of a plan to handle a site located at the same 5 meters above the mean sea level in an Erosional type of coast. If the Kalpakkam coast happens to be a Prograding one, then the measures that are stated above for raising the level of the site to 6.9 meters above the mean sea level would probably be enough; but if it is an Erosional one, then before attempting this work to elevate the level of the site, the AEC should undertake many in-depth studies to determine the extent and the dynamics of sea erosion in this area.

Let us now analyse the statement of the EIA which we have quoted above. This statement says that Kalpakkam site falls at the depositional environment; according to it, the shoreline along the Kalpakkam site is relatively stable. Places around like Oyyalikuppam, CSIF barracks area have experienced sea erosions; but that is only rarely and sporadically. TamilNadu coast in general, is a Prograding coast with a few exceptions like the Mahabalipuram and Royapuram areas.

What do we infer from this?

The EIA seems to tell us that the Kalpakkam site is actually a coastal stretch that is Prograding and relatively stable; while the coastal stretch that is to its north and south are Erosional.

Is this conclusion a correct one? What do the expert Geologists and Geographers in the TamilNadu Coastal Geomorphology and Geography have to say about this Coastal stretch? How have they classified this stretch of the coast?

V.J.Loveson et al., have the following conclusions to make from their study: "In the Coast between Pulicat to Palar river, the extent of the beach ridges are limited. In some places it is found to occur within 4 km inland. The beach ridges are narrow, detached and having less width. Some ridges found near Ennore creek and north of Mahabalipuram are linear and long. Salt affected areas/ coastal low lands occur just next to beach ridges towards inland. The number of beach ridges observed along this coastal area are about three. The less number of beech ridges, along with extensive low lands depict that the area is prone to erosion or the sea is advancing towards land. Accordingly, the recent phenomena of coastal erosion at Thiruvettriyur, north of Madras which claimed several lives and at Mahabalipuram the lowly sinking historical monuments exhibit the erosional behavior of the area in terms of coastal submergence or sea level rise or transgression of the sea." ('Remote sensing application in the study of sea level variation along the TamilNadu Coast, India' in 'Sea level variation and its impact on coastal environment' ed., G.Victor Rajamanickam, Tamil University, Thanjavur, p-184).

Dr.M.Sambasiva Rao, Reader in Geography, SriKrishna Devaraya University, Anantapur has the following conclusions to make: "...Perusal of the coastal landforms, formed along the coastal front of Coromandel coast, depicts that progradation of the coast may possibly be taking place at present along the southeastern coast of Cauvery delta, in between Cuddalore and PortoNovo, Koduru and Sriharikota, along the present delta front of Pennar delta, and in between Nizampatnam and Krishna confluence. Extensive field studies have to be carried out to identify the zones of erosion during different seasons. However, the zones subjected to coastal erosion are very few and are located in and around Madras, Mahabalipuram, Ennoore, Ramayapatnam and Alluru Kottapatinam. Perhaps, in these locations local waves and tides might have plays a significant role for moderate to severe erosion." ('Some aspects of morphology and quartenary sea level changes in coromandel coast of TamilNadu and Andra Pradesh' in ibid, p,287-288).

Apart from these findings, we shall note one *peculiar feature* of the Palar River. ***Among all the Large Rivers of Tamil Nadu, Palar River is the only River which does not have a Delta worth its name.*** Why? This is just because the Coast is sinking in to the Sea; the cause for this might have been due to the tectonics of this *micro-region.* Does this alone not warrant a detailed study before one more Nuclear Reactor is constructed in this area?

We thus see, that these conclusions state clearly that the Region of Kalpakkam falls in a zone of sea erosion and not in a zone of coastal emergence as the EIA wants us to believe.

The EIA does not give any specific evidence that go in favour of its conclusion that this is a prograding coast; even though, the EIA has failed to cite a reference to support its view, we ourselves shall try to cite one reference that tries to back the EIA's view. This is a news item published in the Indian Express on 13-01-2000; it was titled "Satellite picture reveals shift in Palar mouth". It says: "Indira Gandhi Centre for Atomic Research (IGCAR) director Placid Rodriguez, who was in Chennai today, said an imagery from a remote sensing satellite shows that the mouth of the Palar river has moved south ward to Oyyalikuppam through the centuries, 16 kms away from Pooncheri and Mahabalipuram where it existed originally.

The abundance of shells found in the Vasavasamudram village, (described in Sangam literature) was where the mouth of the Palar once existed. The village is three kms north of Oyyalikuppam."

This news item seems to tell us subtly that the Vasavasamudram village was once under the sea because we are able to see an abundance of shells there. So, a process of emergence should have occurred in this coastal area.

Can we come to the conclusion that a coast is an emerging or a submerging one just from one sign namely the presence of an abundance of shells? No. Vasvasamudram, of course has abundant shells, but that does not mean that it was a Sea Port. It should have been a large River Port on the banks of the Palar River when it was still flowing in its old course. A subsequent tectonic instability should have cause the Palar River to move further south, and when this occurred Vasavasamudram should have been left with these shells.

So, the Coastal stretch of Kalpakkam is by every means an Erosional Coast by classification. Even if the site location of the PFBR is raised to a level of 6.9 meters above the mean sea level the AERB can not permit the AEC to proceed further to build the Fast Breeder Reactor; because, before that the AEC should make sure how this site will or will not be affected by the sea erosion. For that they should conduct a very thorough study on the erosional dynamics of the sea beyond.

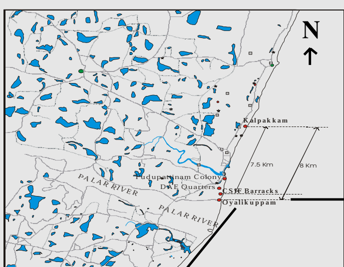
(The sadder aspect of this is that even though the Madras Atomic Power Station and the IGCAR are there at Kalpakkam for the past 30 years, they have not bothered to collect the data on the wave dynamics of the local sea in spite of them using it for disposing their heat and low level rad

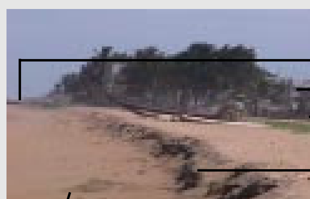
wastes off into it. We are literally bewildered to read in the Mecon EIA that they instead shall be using the wave data collected at the Madras port. How can this be correct when we now know that in Bay of Bengal the range of tide increases with the latitude, owing to the configuration of Bay of Bengal and the depth of the sea bottom? (M.Sambasiva Rao, ibid., p,288); and at many places like Mahabalipuram, it is a known fact that the wave velocity is much higher than elsewhere?).

[Dr.Vivien Gornitz of the NASA GSFC Institute for Space Studies, New York states: "Projected sea level rise within the next 100 years is estimated to range between 0.5-1.5 meters. (NRC,1987). Clearly, this elevation zone faces the highest probability of permanent inundation. Thus, the coastal strip within 5 meters of present mean sea level (PFBR site 3-6 m) lies at very high risk to permanent inundation, as well as above normal tides from severe storm surges. The hazard decreases progressively for higher average elevations." (ibid, p,363-364)].

Sea Erosion at Kalpakkam Region.

Field Study by "DOSE" conducted on 12-07-2001, has revealed that the Sea Erosion at the CSIF Barracks area and at Oyyalikuppam are not Sporadic as claimed by the MECON EIA. It is a regular annual feature of the area; this is said to commence in July and continue upto November.



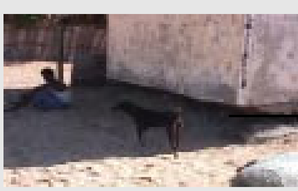


Oyyalikuppam
CSIF Barracks
Bund built to withstand erosion
Eroded Sea Shore

N
To Kalpakkam

Oyyallikuppam Shore

MAPS
Eroded Oyyalikuppam Shore



Eroded Basement of Fishermen Hut at Oyyalikuppam

Fishermen Hut Destroyed by Sea Erosion at Oyyalikuppam

MAPS
Damaged Hut seen in the previous picture

Destroyed Huts

The Last remnants of the Destroyed Coconut Grove

In 1990 the Coconut Grove was present even beyond this Margin

Sea Erosion seen beyond Oyyalikuppam towards Palar River

Chapter 7

Safety versus Unpredictability

3) The Third argument

The EIA tells us that the 500 MWe PFBR that will be built is a safe and a tested reactor. Let us quote in detail the paragraphs in the EIA report that are related to the plant safety.

a) "The technology for design, construction and operation of the Fast Breeder Reactors has been demonstrated at Kalpakkam with the establishment of the IGCAR, where over the past 25 years, a 40MWt (13MWe) FBTR and various research and development laboratories in support of the FBR programme have been setup." (Exe-Sum-1,EIA)

b) "...It is important to note here that large size Fast Breeder Reactors abroad-similar to the one proposed here or even larger- have not posed any technological problems connected with the reactor size." (p,2-6, EIA).

c) "The basic goal of reactor safety is to prevent accidents and if they occur, to detect them early and to mitigate their impact by engineered features that limit the radiation exposure to operating personnel and public to within acceptable levels as defined by AERB. Towards this, systems are designed with the defence in depth approach having redundancy, diversity and independence. The safety measures provided are two diverse reactor shutdown systems, two decay heat removal systems, a core catcher and RCB. Control and safety rod system is used for reactivity compensation, power control and shutdown, while diverse safety rod system is used only for shutdown. Even after the reactor is shut down, there is heat generation in the core due to radioactive decay of fission products, called decay heat, which needs to be removed. Generally, the decay heat is removed by normal heat transport path through Steam Generators. In case of loss of off-site power or non-availability of secondary or sea water circuit, the decay heat is removed via a class I safety grade passive direct reactor cooling system. It consists of four independent circuits of 6 MWt capacity each having a sodium to sodium heat exchanger dipped in reactor hot pool and a sodium to air heat exchanger. A core catcher is provided to collect the molten fuel, disperse it suitably and ensure long term cooling in the most unlikely event of a core melt down. With a similar defense in depth approach, an RCB is provided for anticipated transients without scram (ATWS) which are of event frequency of the order 10^{-6} per reactor year. RCB is designed for 20kPa (200 mb). It has a 0.75 to 1m thick RCC wall. Facilities have been envisaged for in service inspection of main and safety vessels, sodium piping and Steam Generator." (p,2-28, EIA)

d) "The plant layout takes care of the functional requirements like effective access for installation and maintenance. It incorporates several safety related features such as provision of backup control room, physical separation of the two steam generator units, appropriate location of turbine building to guard against accidental turbine missiles and so on.

The important functions of Instrumentation and Control system are to monitor various parameters to guide the operator in all the states of the reactor control certain parameters within limits and take automatic safety actions. A three level control scheme is adopted i.e. field, local control centre and control room. Safety and safety-related systems are monitored and operated from control room and they are designed in fail safe mode. A backup control room is proved to bring the reactor to safe

shut down state in case control room becomes not habitable. Provisions made for monitoring the key parameters of interest are indicated below:

Neutron flux is monitored by fission chambers located in hot sodium above the core. (Fuel) Subassembly outlet sodium temperature is monitored to detect Subassembly fault events (e.g. under cooling). Failed fuel detection is done by monitoring cover gas fission product activity and delayed neutrons in the primary coolant. Provision is made for continuous monitoring of Steam Generator tube integrity by detection of hydrogen in sodium, hydrogen in argon of the surge tank, argon pressure of surge tank etc. For detection of sodium leaks, wire type leak detectors, spark plug leak detectors, sodium ionisation detectors etc. are provided. Reactor is tripped by dropping the absorber rods once safety parameters such as neutron flux, temperatures, flows etc. cross their threshold values. The power is regulated manually through adjustor rod." (p,2-26,EIA).

a) The Experience of building and managing an all time Sick Reactor called the FBTR

The Fast Breeder Test Reactor (FBTR) has been sick most of the time during the last 15 years. It was built with the help of France based on the designs of its Rhapsody Fast Breeder Test Reactor. However many indigenous design changes had been effected. It attained its criticality on 18 Oct'1985. (Vyvyan Tenorio, "India's 40-MWt FBTR Went Critical Late Last Week," Nucleonics Week, 24 October 1985, p. 5; "Indira Gandhi Centre for Atomic Research," (http://www.igcar.ernet.in); Pearl Marshall, "India and France Renew Old Friendship," Nucleonics Week, 4 July 1985, pp. 12-14- quoted in Andrew Koch, Christopher Derrick, and Shelby McNichols' article "Selected Indian Nuclear Facilities" Last modified July 1999,by Monterey Institute of International Studies).

Its original design capacity was 40 MWt (13 MWe); but has rarely operated above 10.5 MWt. The facility has experienced numerous technical problems and shutdowns and was closed from 1987-89 and ran at a mere 1MWt from 1989-92. ("India's Test Breeder Reactor Was Restarted May 11," Nuclear News, July 1989, p. 67; Department Of Atomic Energy Annual Report 1996-1997, Government of India, 1997; "Reactor Group," (http;//www.igcar.ernet.in) quoted in ibid,1999). Later the reactor was reported to have increased its output to 12.5MWt in 1997 which is anyway only 32% of its design capacity. This decreased output was said to be due to an under-sized Fuel core. (Mark Hibbs, "Indian FBTR Operating at 12.5MW, Reprocessing Line Sought by 1999," Nucleonics Week, 10 July 1997, pp. 7-8, quoted in ibid,1999).

Apart from this 'The Hindu' newspaper published a news article, in its March 22, 2001 edition on the recent achievements of this FBTR:

"The Kalpakkam-based Indira Gandhi Centre for Atomic Research (IGCAR) achieved a major milestone when the fast- breeder test reactor (FBTR) was synchronised with the Tamil Nadu grid and was in continuous operation at full power capacity for 53 days from October 28 to December 21, 2000. It was actually synchronised with the grid on October 6, 2000 and was in operation on and off till February 4, 2001. Nearly 7.4 Lakh units of electrical energy were generated during the 53 days of continuous operation."

This is an achievement being announced exactly after 15 years since it attained its criticality. That too it was a short-lived achievement. After functioning continuously for 53 days from Oct'28-Dec'21,2000, it is said to have operated on and off till Feb'4,2001. What about the period that followed up to say March 19th? The news report does not talk about this.

It is said that during the 53 days of continuous operation, about 7.4 Lakh Units of electricity was produced. This sounds very peculiar.

7.4 lakh units = 740,000 kWh. If it ran continuously for 53 days, then it ran for 53 X 24 = 1272 hours. In that case the power it was generating was only 740,000/1272 = 581 kW and

not the design value of 13 MWe. Can this be true? Or, is it an incidence of typographical error or just another case of mis-reporting? (M.V.Ramana, personal communication).

"Of course this is neither misreporting or a typographical error. The point that IGCAR wanted to emphasise in this was the NON-STOP operation of the FBTR for 53 days. It didn't claim that it was running at its full capacity. Yes. It was functioning at a reduced capacity; the FBTR could not be run in its full capacity because the Plutonium for loading the core fully was not available. Running at a full capacity is nothing more than a mere extrapolation of what we had done in those 53 days," retorted a scientist connected with FBTR in response to the foregoing argument; but in the next moment another scientist connected to the reactor said: " Running FBTR with its core fully loaded is definitely a different situation to running it with its partially loaded core. The reason is, when the Core is fully loaded, the amount of heat that will be generated will be much higher than what we have experienced so far; and at this higher temperatures we do not know how the metals that we have used for constructing the fuel pins, coolant pipes will behave. Hence, I will never agree to the statement that we now have enough experience to build larger Fast Breeders. The experience that we have is only on running a small test reactor with its partially loaded core. That's all. Let us accept it stright away."

It is with this experience that the IGCAR is going forward to construct a Fast Breeder Reactor that is almost 34.46 times larger than this present FBTR!

The IGCAR should have planned to run the FBTR with its fully loaded core and should have tried to study the behaviour of metals in such a condition; that would have been the right "scientific" decision; but instead it is moving forward with the construction of a much larger Fast Breeder with a fuel (that is MOX; it has been handling Mixed Carbide Fuel till now at the FBTR) with which it actually has very little hands-on experience.With all this, how do these scientists want us to accept this project?

b) "Large size Fast Breeder Reactors abroad-similar to the one proposed here or even larger- have not posed any technological problems connected with the reactor size".

Is this statement correct?

We have five countries that have taken a similar course of building large capacity fast breeders after operating a test reactor for a few years. They are: the USA, UK, France, Japan and Russia.

Out of these five countries, Russia's fast breeders use Highly Enriched Uranium instead of the MOX Fuel.

USA

The case of USA is quite disturbing. It built the first Fast Breeder Reactor of the world and in fact this was the first nuclear reactor to produce a modest amount of electricity. This was called the EBR-I reactor and started operating from the year 1951. (Loeke Pam et al., The MOX Myth -The dangers and risks in the use of mixed oxide fuel, wiseamster@antenna.nl April 1997, p-8) In 1955, the reactor became uncontrollable and subsequently went into a super critical or a prompt critical mode; its core melted down, and the reactor got destroyed. (Mauricio Schoijet, 'Sociology of Nuclear Accident-Facts and Conjecture', in Philosophy and Social Action, 26(4)2000, p-16). However, this accident did not stop the construction of a much larger 2nd Fast Breeder reactor; it started in the very next year (1956). This was the Enrico Fermi Fast Breeder Reactor with a power of 200 MWt. It started operating from 1963 onwards, but met with a major accident on Oct'5th, 1966; the accident was a partial meltdown of the fuel core; it took 1-1/2 years to work out the cause of the accident. Several pieces of sheet metal had broken off the bottom of the reactor vessel and were swept up in the coolant flow, causing a blockage. The reactor had been operating at 15% of full power since then and was afterwards decommissioned in 1972. (("Les Amis de la Terre"; Penelope Coleing for M.A.U.M., Jean Geue A.A.E.C.- quoted in the Compilation of Nuclear Accidents from the year 1945-1991, by Awareness Education for the Office of Jo Vallentine Senator for

The Greens (WA), Australia). Even this 2nd accident couldn't stop the American nuclear industry to go in for another Fast Breeder. This was the Clinch River FBR; its construction was started in the year 1976, but was cancelled in 1983 as a (late) consequence of President Carter's Nuclear Non Proliferation Act of 1978. (Nucleonics Week, 3 November 1983: 'U.S. Breeder establishment picking up the pieces in wake of CRBR's fall, p-8, quoted in Loeke Pam etal., p-20). The US as for today has 2 Fast Breeder Reactors; they are of a very small capacity. The one that is operating (from 1963) is the EBR-II reactor, and this is just a pilot plant of 62.5 Thermal capacity. The other Fast Breeder reactor is of a slightly larger 400 Thermal capacity. This is the FFTF Reactor which attained its criticality in the year 1982; this Reactor is not currently operating but is put in a hot standby from the year 1992 onwards. (Loeke Pam etal., p-9).

So, the questions that follow are: Why did the USA denounce its exaggerated ambition of 60s' and 70s' to build larger capacity FBRs? What forced it to be content with just one Fast Breeder Pilot plant now? The answers to these questions are only too obvious.

UK

In the UK, there were 2 FBRs that were operating. Today both have been closed. The Dounreay Fast Reactor, 15 MW, was closed in 1977, the 270-MW PFR, also at Dounreay, was closed in 1994 because the government stopped funding it. Expenditure for research and development of FBRs totalled 4 billion pounds from 1960-1995. [Nuclear Europe Worldscan, no.1-2 1993: 'UK plans orderly, scientific withdrawal from fast reactor R&D',p.58]. This is some US$6 billion in January 1993 exchange rates. Why did this actually happen, in spite of the reason that the country had spent such a huge sum of money?

In October 1967, the Prototype Fast Reactor at Dounreay had to reduce its power because seaweed had entered the cooling water pump house. It had passed through a special 2 million pound (U.K.) seaweed barrier, built only last year. (SCRAM Journal (Scotland) Nov/Dec 1987, WISE 283, 20/11/87). In 1977, 10th May, a reaction between water and 2.5 kilos of sodium lifted the concrete covers off a solid waste disposal facility at the Dounreay site. (Thieberger, p.12).In 1987, December 9, a worker at the Dounreay PFR (prototype fast reactor) reprocessing plant received a "significant" dose of radiation to his hand in an accident. Although the contaminated worker was wearing full protective clothing and was not directly contaminated, the radiation dose which penetrated his glove was in excess of the safety limit. ("SCRAM Journal" (Scotland) March/April 1988). In 1990 April, The Dounreay fast breeder reactor was closed down after liquid sodium leaked from the secondary cooling system and burnt on contact with air. (NENIG Briefing (P.A.) 5/90. WISE 333 1/6/90). All these problems along with the frequent shutdowns that these reactors underwent, became so unbearable for the UK Government that it closed down both these FBRs without even bothering to think about the money it had pumped in for their research and construction.

France

The case of France proves the falseness of the statement that the larger capacity fast reactors do not face new technological problems compared to the pilot fast breeder plants.

Rhapsody, a small experimental Fast Breeder Reactor (on whose design the FBTR is built) of France faced a severe accident in March, 1994. During the dismantling of this reactor, an unexpected reaction involving about 100 kg of sodium led to a violent explosion. One technician died and four others were severely injured. Since Rhapsody was only a small experimental reactor, the magnitude of the accident was limited. (M.V.Ramana, 'Dangerous encounters', in The Hindu, 21-11-1999).

The other Fast Breeder Reactors in this country are Phoenix and Super-Phoenix. Phoenix's capacity was 250 MWe and the Super-Phoenix's capacity was 1242 MWe. Phoenix started operating from 1974, and the Super-Phoenix from the year 1988.

What were the technological problems that these two larger reactors faced?

Most of the time these reactors were shut down, under repair or functioned for less than half of their power. It was debated in the mid 90s, that the Super Phoenix will not (try to) breed anymore and will be rebuilt into a research reactor for burning Plutonium and transmutation of other actinides. (NucNet News Item, 20 December 1996; 'Super phoenix Set For Breeder-to-Burner Conversion', quoted in Loeke Pam etal., p-14); along with this, a 1996 report by the Cour des Comptes, a watchdog office that oversees government spending, said the Super phoenix has cost the State some 60 billion francs and questioned the 'usefulness.., of this equipment"; but the French Government ultimately took the decision to close down the reactor on 02-02-1998, and the de construction is all set to begin in 2005, and this would cost 10.6 Billion Francs. It is to be noted here that this largest fast breeder reactor of the world was able to produce only a 6 months of electricity for a whole period of 12 years. (AP,03-02-1998). Phoenix in its turn, is now used not for electricity generation, but for Pu-burning research and the incineration of actinides.

What forced the French to convert their two commercial reactors into research reactors?

The reason is none other than the accidents that plagued these two reactors.

"In 1975, October the Phoenix Fast Breeder Reactor was closed due to Sodium coolant leak."

"In 1976 July, again the Phoenix Reactor developed fault in heat exchange between primary and secondary sodium cooling circuits." "Sodium leaked from a cooling tank at the Super phoenix fast breeder reactor in Creys-Malville on 8 March, 1987 and engineers have been unable to trace the source of the leak. ("La Monde" 11/4/87, "Guardian" 13/4/87 - WISE April 1987)." "In 1989, from August to September, a bubble of argon gas in the core of Phoenix fast breeder reactor led to a near major explosion without engineers realizing the danger even though the reactor shut off automatically three times during this period for undetected reasons. If the bubble had arisen more in the centre of the core a Chernobyl like power excursion disaster would have been possible. Despite French Authorities denying this it was referred to in the safety report of the German fast breeder SNR-300 at Kalkar. (taz (FRG) 13/1/1990; WISE 326/7 9/2/1990)". "In 1990, 16th September the French Government has been forced to close a fast-breeder nuclear power reactor -the Phoenix- in Creys-Malville after a series of technical problems climaxed in reduction of power and automatic shutdown. The accident rated 2 on a severity scale of 6. It was thought that a bubble of argon gas in the reactor core was causing the trouble. The Superphoenix fast breeder was also in trouble with an unrelated problem of corrosion product contamination in the primary sodium coolant. Neither reactor was expected to restart until late 1991 at the earliest. (The Australian, 19/9/90, Nuclear News, August 1991).

So, unable to cope up with the unpredictable nature of the Fast Breeder Technology, France has almost scrapped its Fast Breeder Programme today.

Japan

Japan has 2 FBRs, one Joyo-a small 100 thermal capacity test reactor, and the other Monju- a 300MWe FBR. Joyo started operating since 1976, and Monju from early 1995. Monju had to close down on 8 December 1995, only a few months after its start-up because of a major fire in its secondary sodium coolant channel. Since then, up till today it remains closed. As the FBR programme got stalled the countries' Plutonium stocks had piled up to 15,000 kgs in 1995. The Govt., later had to take the decision of burning all this in 18 Light Water Reactors. By 2010 all 18 LWRs will use MOX fuel. This is a clear policy shift from the earlier emphasis to burn plutonium in Fast Breeder Reactors.

Joyo Test Reactor has operated from 1976 but Monju FBR was able to operate only for a few months. Is this not a case of the Technological problems connected with the construction of a larger sized reactor?

Russia

Russia's Fast Breeder Reactors use Enriched Uranium in place of MOX as their Fuel. The first Soviet breeder reactor, an experimental 200-kilowatt unit, began operating in 1956 at the research and design center at Obninsk. The reactor was eventually upgraded to a 10-megawatt model. A 135-megawatt breeder, BN-300, has operated since 1972 in Kazakhstan at Aktau (formerly Shevchenko) on the Caspian Sea. The unit also desalinates about 80,000 tons of water each year for the city of Aktau. The plant was troubled by a sodium/water reaction in 1975 that resulted in a two-hour sodium fire. This reactor was shut down in 1994 as Kazaksthan didn't have money to buy fuel for the reactor and pay the wages for its employees.

Russia's second Fast Reactor was called BN-600, and is located at Beloyarsk. Its capacity is 560 MWe and is the second largest Fast Reactor in the world. It started operating from November 1981 onwards.

This Beloyarsk BN-600 Fast Reactor has faced many accidents since then. In December 1992, radioactive water from the liquid radwaste storage tank was spilled during transfer and seeped into the plant cooling pond. Th incident was classified as Level 2 on the International Nuclear Event Scale (INES). In October 1993, the plant was shut down following a sodium leak in an auxiliary system. A fire occurred in a cleanup circuit for the primary sodium. In November the same year, the plant was shut down after an increase in radiation levels was detected in the exhaust fan system. The problem was traced to a sodium leak from one of the auxiliary cooling systems. In May 1994, a fire broke out at the plant, which was shut down for repairs at the time. Sodium from the secondary circuit piping leaked and caught fire on contact with air. In July 1995, a sodium leak from one of the reactor's secondary circuits caused a shutdown of the unit for about two weeks. (*"Source Book: Soviet-Designed Nuclear Power Plants in Russia, Ukraine, Lithuania, Armenia, the Czech Republic, the Slovak Republic, Hungary and Bulgaria" Fifth Edition ,1997, Nuclear Energy Institute Suite 400 1776 I Street, N.W. Washington, DC).*

What do all these accidents in larger capacity fast breeders tell us?

"The accelerated construction of larger reactors, from the order of less than one to hundreds of megawatts in less than twenty five years didn't provide enough time for an accumulation of knowledge on their operation problems. This is a characteristic of nuclear reactors, probably a product of an ideology of omnipotence of science and technology and of the acceleration of scientific and technological progress, that might have contributed to create the conditions for nuclear accidents.

In the case of the steam engine, it evolved for two hundred years before reaching its present larger sizes. In the 19th century boiler explosions were still frequent, now they do not happen. The complexity of nuclear reactors and the dangerousness of the materials that they use makes it probable that the efforts and time required to achieve safety might be larger than in the case of the preceding thermal engines.

The accelerated scaling up of the nuclear reactors was not affected by the (history of the) accidents that had happened (in this type of reactors). This shows the irresponsibility, adventurism and irrationality which characterise the history of nuclear power." (Mauricio Schoijet, 'Sociology of Nuclear Accident-Facts and Conjecture', in Philosophy and Social Action, 26(4)2000, p,30-31)

c&d) The Reactor has inbuilt safety features

"By monitoring the key parameters (that denote an accident) like the Neutron Flux in the reactor core, Fuel subassembly fault events (like undercooling), Failed Fuel, Steam Generator Tube integrity, and Sodium leaks the reactor can be tripped immediately by dropping the Control Rods. The decay heat can then be removed through the conventional heat transfer cycle or through the Passive Reactor Cooling System. The molten fuel in the case of a core meltdown can be dispersed and its long term cooling can be ensured by the core catcher. The RCB can withstand transients

without scram and can resist a pressure of 20kPa."

This statement on the Safety features of the PFBR sounds wonderful. To understand, what each one of the events mentioned in the above paragraph mean, we shall look into the accident history of the Fast Breeder Reactors around the world.

The accidents can be grouped into three categories. They are: accidents pertaining to the Fuel core; accidents related to the coolant liquid and the channels; accidents other than these two.

We can cite many examples for each category.

The first category of accidents that are related to the fuel core occurs when the burning of the fuel core becomes uncontrollable and the nuclear chain reaction occurring in it enters into a Super or prompt critical mode thus causing the temperature of the core shoot up manifolds suddenly; this will make the coolant to boil which in turn may precipitate an accident. The Second category of accidents occur due to the loss or block of the reactor coolant flow; these events are capable of damaging the fuel core; this event causes the core temperature shoot up which in turn may precipitate a core meltdown.

Apart from the core melt that the coolant (here it is the liquid sodium) loss is capable of causing, it can also react with water and cause fires inside the plant. The third category is due to the causes other than these two.

Now we shall go through the examples for each category.

The accidents due to a loss of control of the Burning of the Fuel Core:

-EBR-I of the USA became uncontrollable in 1955 and went into a super or prompt critical mode; this caused a core meltdown and the reactor eventually got destroyed.

-In 1989, from August to September, a bubble of argon gas in the core of Phoenix fast breeder reactor led to a near major explosion without engineers realizing the danger even though the reactor shut off automatically three times during this period for undetected reasons. If the bubble had arisen more in the centre of the core a Chernobyl like power excursion disaster would have been possible.

-In 1990, 16th September the French Government has been forced to close the Phoenix fast-breeder reactor, in Creys-Malville after a series of technical problems climaxed in reduction of power and automatic shutdown. The accident rated 2 on a severity scale of 6. It was thought that a bubble of argon gas in the reactor core was causing the trouble.

The accidents due to a loss or block of the coolant flow:

-The 2nd FBR of the USA, the Fermi, experienced this type of an accident in 1966. Several pieces of sheet metal had broken off at the bottom of the reactor vessel and were swept up in the coolant flow, causing a blockage. This caused a partial meltdown of the reactor core. It forced the reactor to reduce its capacity to just 15% of its original one for the next 6 years. The reactor was eventually closed down in 1972. It took nearly 11/2 years for the engineers and the working scientists of the Fermi, to find out the cause of this accident.

-In 1975, October the Phoenix Fast Breeder Reactor was closed due to Sodium coolant leak.

-In 1976 July, again the Phoenix Reactor developed fault in heat exchange between primary and secondary sodium cooling circuits.

-Sodium leaked from a cooling tank at the Super phoenix fast breeder reactor in Creys-Malville on 8 March, 1987 and engineers have been unable to trace the source of the leak.

-In 1990, the Superphoenix fast breeder was in trouble with a problem of corrosion product contamination in the primary sodium coolant forcing it to shutdown its operation.

-In 1990 April, The Dounreay fast breeder reactor of the UK was shut down after liquid sodium leaked from the secondary cooling system and burnt on contact with air.

-Germany started building its ambitious FBR project at Kalkar near its Dutch border and

almost completed it in 1991; the accidents that strike every FBR of the world, struck this project even before its completion. A sodium fire occurred in this reactor in November, 1984. According to official reports, the accident occurred when argon gas was vented from a sodium holding tank which drew 190 liters of sodium with it to the roof of the reactor building. When the sodium came into contact with the moisture it ignited and 100m^2 of the temporary roofing caught fire. ("Atom" Mar/ Apr 85, WISE NC 223 1/3/85). So, Germany at last decided not to open this newly built reactor, and it is functioning as a luna park today! (Greenpeace Nederland: 'Het einde van de plutonium droom', 1996, p.6).

-Rhapsody, a small experimental Fast Breeder Reactor (on whose design the FBTR is built) of France faced a severe accident in March, 1994. During the dismantling of this reactor, an unexpected reaction involving about 100 kg of sodium led to a violent explosion. One technician died and four others were severely injured.

- The Monju FBR of Japan, had to close down on 8 December 1995, only a few months after its start-up because of a major fire in its secondary sodium coolant channel. Since then, up till today it remains closed.

- The accidental experience of the Russian BN-600 Fast Breeder Reactor mainly involves the integrity of the coolant channels. In October 1993, the plant was shut down following a sodium leak in an auxiliary system. A fire occurred in a cleanup circuit for the primary sodium. In November the same year, the plant was shut down after an increase in radiation levels was detected in the exhaust fan system. The problem was traced to a sodium leak from one of the auxiliary cooling systems. In May 1994, a fire broke out at the plant, which was shut down for repairs at the time. Sodium from the secondary circuit piping leaked and caught fire on contact with air. In July 1995, a sodium leak from one of the reactor's secondary circuits caused a shutdown of the unit for about two weeks.

Accidents due to other causes

-In October 1967, the Prototype Fast Reactor at Dounreay had to reduce its power because seaweed had entered the cooling water pump house. It had passed through a special 2 million pound (U.K.) seaweed barrier, built only the year before.

What do all these accidents indicate?

They indicate that in spite of having highly advanced monitoring programmes to identify the early signs of accidents, and technologically advanced features for maintaining Plant safety, the Fast Breeder Reactors have remained highly accident prone. Some of the accidents have been of very serious consequences too.

One basic issue that we note in many of these accidents is that they couldn't be detected early! Also, in many of these accidents, it has taken a very long time to even to find out the basic cause of the accident!!

It is here, the article on the "Sociology of Nuclear Accidents" by Mauricio Schoijet (in Philosophy and Social Action, 26(4)2000, p,30-31) come to my mind again.

It argues that, "...the worst possible accident is not a Loss Of Coolant Accident (LOCA), but a loss of control followed by a transition to a super critical mode*. Such an event might increase the

** For a nuclear reactor or a bomb we need a critical mass of fissionable material, otherwise no chain reaction can start. After a nucleus undergoes fission, two types of neutrons emerge. The so called fast or prompt do it immediately, the so called slow or thermal or delayed neutrons take several seconds. If the chain reaction is dominated by the slow neutrons, we have the critical or normal mode of operation of a nuclear reactor. If for some reason it shifts towards fast neutrons, this is called a super critical or prompt critical mode, in which the reaction rate and therefore the energy released can increase in a very short time, of the order of one tenth of a second, to hundreds or even thousands of times the normal rate. This will destroy the reactor, or the reactor core, in a few seconds. (p-10)*

power thousands of times with respect to the normal mode of operation in a time of the order of seconds, causing a heat transfer to the water (here the Liquid Sodium) which might cause a Steam Explosion I, which would destroy the reactor." (p-28).

"(Or)...if the reactor goes into a super critical mode a Nuclear Explosion could happen, that we would call Nuclear Explosion I. Although the energy released in such an event might be small in relation to the energy that would be released if a nuclear bomb would be built using the same amount of fissionable material, it might be enough for blowing up the reactor and any existing containment structure. This possibility has never been acknowledged in any of the nuclear engineering text books.

The possibility of what we would call a Nuclear Explosion II, i.e. a nuclear explosion caused by the molten fuel forming a critical mass following a meltdown, was acknowledged for the case of the Fast Breeder Reactor by Hans Bethe, a Nobel Laureate and a pioneer scientist in the early stages of the development of Nuclear Power.

It should be remembered that a Fast Breeder Reactor uses a more enriched fuel, therefore a smaller amount of fuel is required to achieve criticality. Bethe carried out calculations of the energy released in such an explosion, suggesting that it might be of the order of that of 200kg of conventional explosives for a medium size reactor. (Fuller 'We Almost Lost Detroit', Ballantine, New York (1975)." (p,12).

"...There are no reasons for believing that a Chernobyl type accident could not happen again, because we do not know all possible causes that might lead to a transition to a super critical mode, much less how to confront them.

It has been suggested that an intrinsically safe reactor could be built, that if necessary would prevent an accident from happening by flooding the core with a solution containing a neutron absorber (here the dropping of Control Rods).

This proposal operates within the framework of the LOCA assumption. In the first place, there is no guarantee against flux obstruction. But more important, any hydraulic system operates within times in the range of one thousand seconds, while the transition from the critical to super critical modes occur in times from milliseconds to seconds."(p,31-32)

"There is no reason to believe in the rhetoric of nuclear safety about multiple contention barriers, as both SL-I (of Idaho, USA) accident (in 1961), and the Chernobyl accident suggest that a reactor can explode with a power that would be enough to destroy both the reactor and any actually existing containment." (p-31)

"The safety of operations of commercial nuclear power reactors in the United States has probably improved after the Three Mile Island accident, as a result of a decree of supervision which makes it probably the most heavily supervised industrial operation in history." (p-20).

These improvements are not enough for imagining that serious nuclear accidents cannot happen in the future." (p-31).

Chapter 8

An EIA without a Health Impact Study

We shall now proceed to examine the claims of the EIA on the Routine interactions of the PFBR with the Kalpakkam Regional environment.

A special note is necessary here. When we talk about the interactions of the PFBR with the environment around, we should also consider the environmental impacts of the Spent Fuel Reprocessing Plants-KARP and FRFRP- and the MOX Fuel Fabrication Plant. This we should do because the Reprocessing Plants and the MOX Fuel fabrication plants are particularly doing their job only for the Fast Breeders present at this site. If the Fast Breeders are shut down, then these plants will not have any work to do.

The MOX Fuel Cycle and the Radioactivity of the Region

The spent fuel from the MAPS reactors will be transported to the Kalpakkam Reprocessing Plant (KARP). The KARP will reprocess this and separate out Plutonium 239 in which there may be around 15-20% Plutonium 240 isotope present as a contaminant. This separated out Plutonium will then be taken to the MOX Fuel Fabricating sol-gel pilot plant for the fabrication of the MOX Fuel. Here the Plutonium and Depleted Uranium (? here Natural Uranium) shall be used to fabricate the Fuel subassembly. Here, Thorium will also be handled (as that will be placed as the Blanket in the fuel subassembly). Chemicals like Boron Carbide will also be handled in large quantity by this facility, as this will be used as the neutron absorber. The fabricated fuel subassembly will then be shifted from here to the PFBR, and this shall occur once in 8 months. The spent fuel of the PFBR will be taken to the Fast Reactor Fuel Reprocessing Plant (FRFRP) once in 3 years for further reprocessing. The low level liquid wastes will be pumped into the sea; The gaseous rad wastes will be sent into the atmosphere through the stack. Intermediate and high level liquid and solid wastes will be transported to the Central Waste Management Facility.

The amount of Plutonium needed for 8 months will be 0.67 Tons (~37.5 Tons for 45 years) (this, after considering that the reactor will remain shut for fuel reloading for 2 months); the amount of Natural Uranium that will be needed for this period will be 8 Tons (~360 Tons for 45 years). The amount of Boron Carbide that will be used once in 15 years will be 25.56 Tons (~76.68 Tons for 45 years). (p,5-20,EIA). For getting the above said amount of Plutonium the amount of MAPS spent fuel that should be reprocessed every year will be around 333 Tons (~ 14,985 Tons for 45 years).

The question here is, can the Kalpakkam region cope with the pollutants that will be released due to this Fuel cycle?

The Mecon EIA states in response to this question that each plant inside the Kalpakkam Nuclear Complex has been apportioned a maximum permissible emission rate, and that till now all of them have stuck to these norms.

It then goes on to analyse the past records of radioactivity due to various elements as recorded by the Environmental Survey Lab. (ESL) of Kalpakkam. It presents the ESL records pertaining to the radioactivity due to the presence of Cesium and Strontium in the Diet Components in the four

Environmental Radioactivity in Diet Components of Kalpakkam Region1993-1998,
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(p,4-72 and 4-73, EIA)

Matrix	Zone No.	137 Cs					90 Sr			
Rice (Bq/Kg Fresh)		GM		GSD			GM		GSD	
		1993	1998	1993	1998		1993	1998	1993	1998
	1	0.36	0.73	1.6	1.4		0.06	0.028	2	1.1
	2	0.5	0.38	1.7	3.1		0.03	0.03	1.2	1.3
	3	0.37	0.57	1.4	1.4		0.04	0.05	1.5	1.8
	4	0.3	0.59	2			0.05	0.03	1.7	
Vegetables (Bq/Kg Fresh)										
	1	0.36	0.42	2	2.3		0.08	0.08	2	2.1
	2	0.33	0.76	1.3	1.7		0.05	0.15	1.3	3
	3	0.25	0.61	2.3	2		0.15	0.09	2.5	2.1
	4	0.41	0.53	2	2		0.09	0.07	2.7	1.4
Milk (Bq/Litre)										
	1	0.24	0.28	1.2	2.2		0.04	0.04	1.3	1.6
	2	0.27	0.16	1.7	1.7		0.03	0.03	1.4	1.6
	3	0.27	0.21		1.7		0.03	0.02	1.2	1.1
	4	0.24	0.2	1.4			0.03	0.026	1.3	1
Fish (Bq/Kg)										
	1	0.14	0.21	1.3	1.4		0.11			
	2	0.17	0.19	1.6	1.7		0.11			
	3	0.14	0.15	1.3	1.3		0.11			
	4	0.15	0.17	1.4	1.4		0.11			
Salt (Bq/Kg Fresh)										
	1	0.07		1.4			0.09		2	
	2	0.07		1.4			0.09		2	
	3	0.07		1.4			0.09		2	
	4	0.07		1.4			0.09	0.18	2	
Drinking Water (mBq/Litre)										
	1	2.1	2.7	1.9	1.7		5.5	<1	1.3	
	2	1.2	2	1.3	1.6		4.9	1.1	1.7	1.2
	3	1.4	2.7	1.4	2.1		2.6	1.2	1.5	1.3
	4	1.8	3.1	1.8	1.8		3.6	1.1	2	1.2

zones around Kalpakkam (Zone 1 is 1.6 to 4.8 km, Zone 2 is 4.8 to 8 km, Zone 3 is 8 to 16 km, Zone 4 is 16 to 32 km) for the years 1993 and 1998. It presents the Radioactivity due to these elements released in the Air route for the period between 1985 to 1993. The records for the Tritium concentration in Air and Drinking Water are presented for the years 1990 to 1999. Radioactivity levels in Soils and Grass samples are presented for the year 1998.The record for the external radiation levels within the Kalpakkam site is given for the year 1998. The record for the External, Internal and Total doses of Radioactivity received by the people living in the 4 zones is then presented for the years 1985 to 1998. It states that the average external dose from the presently operating facilities at Kalpakkam is only 30 micro Sieverts/annum and that the PFBR will contribute an additional dose of about 12.5 micro Sv/annum (p,5-29). The EIA also presents its own measurements of Radioactivity due to Alpha, Beta particles and Tritium found in the surface, Ground and Sea Water done for the period Aug-Oct 1999. It concludes in the end that all these records show that the radioactivity has not increased significantly in this region from the radioactivity level found in the year 1974 (preoperational level). Hence it asks us not to get worried.

That at first, seems to be a fine piece of argument; but when we look closely into the data presented we notice two main stumbling blocks for a true spirited scientific enquiry.

The first block is due to the Time-Periods of the various data presented. They are not uniform and so no comparison between the radioactivity due to various elements and routes is possible. We, for example, cannot posit a comparison between the extent of increase in the level of Strontium/ Cesium found in the Diet Components of the Region to the extent of increase in the level of Tritium found in it since the values given for Tritium runs from 1990-1999, and the values for Sr/Ce is only for the years 1993 and 1998. The data on the radioactivity level in the Soils and Grass is given only for the year 1998!

Maintaining a uniform time-period for all the data sets is bound to tell us whether there is any uniform increase or a decrease of radioactivity in the region due to the various elements over the years; if the radioactivity contribution due to a few elements is increasing, and that due to others are decreasing we will be able to ask the question as to why this should be happening, and then try to answer that question. Such an act is not at all possible if we are to take for our enquiry the data sets presented in the EIA.

The second stumbling block for a scientific enquiry of the region is that data on the contribution of radioactivity from some important elements are not presented at all. The data for the radioactivity due to ^{131} Iodine is not found anywhere in the report; this, in spite ^{131}I being one of the prime radioactive elements routinely released from the nuclear power plants; the ESL,Kalpakkam is said to routinely measure the level of ^{131}I present in the Goat Thyroid collected from the meat shops of Pudupattinam and Mahapalipuram, but their data is not presented here at all!! It has also not presented the radioactivity found in the beach sands of the shore areas located at varying distances from the site. Apart from this, the data on the radioactivity due to Ce/Sr in the salt is given only for the year 1993, and the data for the year 1998 is not given at all.

Third, and the most important parameter of all is that it does not talk about the present and the past disease pattern of the human, animal and marine population of this region at all. What was the pattern of diseases in this region for all these living organisms in the year 1974? How is all this changing or not changing over all these years? This parameter should have been given the highest priority in the EIA but alas! it does not find even a mention!!

In spite of this, when we go through these data we notice certain important points. (The EIA of course does not mention these issues.)

Let us at first present the data on the radioactivity due to Strontium and Cesium in the Diet

Mean Dose to Members of Public (Micro Sv/annum) *(External Dose due to ^{41}Ar Release from MAPS; Int. dose due to Inhalation and Ingestion of ^{3}H. (P,4-79, EIA).*

Year	At 1.6 Km			Mid point of 1.6-4.8 Km			Midpoint of 4.8-8.0 km			Midpoint of 8.0-16.0 km			Midpoint of 16.0-32.0 km		
	Ext	Int	Total	Ext	Int	Total	Ext	Int	Total	Ext	Int	Total	Ext	Int	Total
1985	10.4	0.7	11.1	3.9	0.7	4.6	1.5	0.7	2.2	0.5	0.7	1.2	0.2	0.7	0.9
1986	48.8	0.7	49.5	18.3	0.7	19.0	7.1	0.7	7.8	2.5	0.7	3.2	0.8	0.7	1.5
1987	85.6	0.7	86.3	31.6	0.7	32.3	12.3	0.7	13.0	4.3	0.7	5.0	1.5	0.7	2.2
1988	77.4	0.7	78.1	30.3	0.7	31.0	12.1	0.7	12.8	4.4	0.7	5.1	1.5	0.7	2.2
1989	33.4	2.0	35.4	12.0	1.0	13.0	4.4	1.0	5.4	1.4	0.7	2.1	0.5	0.7	1.2
1990	57.9	1.5	59.4	21.4	1.3	22.7	8.2	1.1	9.3	2.0	0.7	2.7	1.0	0.7	1.7
1991	49.6	1.0	50.6	18.4	0.8	19.2	7.0	0.8	7.8	2.4	0.7	3.1	0.9	0.7	1.6
1992	50.1	0.8	50.9	18.4	0.8	19.2	6.8	0.8	7.6	2.2	0.7	2.9	0.8	0.7	1.5
1993	24.7	0.8	25.5	10.0	0.8	10.8	3.6	0.8	4.4	1.3	0.8	2.1	0.4	0.8	1.2
1994	46.7	1.1	47.8	18.6	0.8	19.4	6.7	0.8	7.5	2.3	0.7	3.0	0.7	0.7	1.4
1995	20.9	0.9	21.8	8.1	0.8	8.9	2.7	0.8	3.5	0.9	0.7	1.6	0.3	0.7	1.0
1996	27.5	1.2	28.7	11.1	0.9	12.0	4.0	0.8	4.8	1.4	0.7	2.1	0.4	0.7	1.1
1997	27.4	1.6	29.0	11.3	1.0	12.3	4.2	0.9	5.1	1.5	0.8	2.3	0.5	0.7	1.2
1998	29.4	0.6	30.0	12.2	0.5	12.7	4.6	0.3	4.9	1.6	0.3	1.9	0.5	0.2	0.7

Components for the years 1993 and 1998. (The data columns are rearranged for a better comparison).[see the Table on p-35]

We see in the following table that the level of ^{139}Cesium has increased dramatically over the 5 years for Rice, Vegetables, Fish and the Drinking water of the region. The ^{137}Ce level in the Milk has not increased but is showing a minute decrease. As for as the Salt is concerned, the Table is not giving us the data for the year 1998.

Let us now move on to ^{90} Strontium. In contrast to ^{137}Ce, the Table tells us that the radioactivity due to this element is showing a slight decrease.

Why should such a dramatic increase in the radioactivity due to Cesium and a slight decrease in the radioactivity due to strontium occur in the first place? The EIA has neither posed this question nor has an answer for it.

Let us now consider the data on the Mean Dose to Members of the Public of the Kalpakkam Region from the year 1985 to 1998.[see the Table on p-37].

This data set tells us that there was an abrupt heavy rise in the mean dose in the year 1986. It reached its peak in 1987 which gradually decreased up to 1994. This sudden increase, it is said elsewhere in the EIA, was mainly due to the increased release of ^{41}Argon during the above years; The amount of ^{3}H released during this period had also shown a slight increase during this period. The dose of radiation due to Tritium had almost raised 21/2 times the value of 1985 in the year 1989. This fell down gradually from then till the year 1998 but also showed 2 spikes in between; one in 1994 and the other in 1997. The general trend for both the gases is a gradual increase in their emission value over the years.

This is again confirmed by the Tables on the Tritium Concentration in the Air and Drinking Water of Kalpakkam. (Tables 4-40 and 4.41,p,4-75 and 4-76,EIA). The EIA notes NONE of these in its report.

What does this indicate?

It indicates that the Kalpakkam Region is NOT receiving a regular, non-changing and a uniform amount of Radiation from its currently operating Nuclear Power Plants.

When and Why exactly did the Radioactivity increase in this area? This has to be analysed in depth immediately before adding one more Reactor to this Region; apart from this, an effort should be made to correlate this increase with the Morbidity and the Mortality Pattern among the Human, Animal and Marine population of the Region. Only after all these works are done, can we start believing that the normal & the routine actions of the region's Reactors are not and will not be harmful to us.

This work is an urgent one; because, from the mid 70s' many studies are confirming an increased incidence of Cancers among the population working and living around the Nuclear power plants.

Even though the Indian Nuclear Establishment is denying that the Low Dose Radiation around Nuclear Power Plants can be harmful, there are now studies especially in the UK and France that tell us otherwise. We shall now go through these studies in order to know what sort of analytical work that we should undertake at the Kalpakkam Region before constructing another reactor.

Nuclear Reactors and the increased incidence of various Cancers

History:

The necessity to study this relationship arose in the USA in the early 60s'. The Atomic Energy Commission of the USA was put under a great political pressure to conduct such a study and prove to the nation that the workers of its nuclear plants were not facing any increased risk of contracting to various forms of Cancers. This was bound to be a long term epidemiological study and it was given to ***Dr.Thomas Manusco***, a pioneer in Occupational Health Studies. This was in 1964.

In this portion, on the works of Dr.Manusco, I shall quote at length from the 1982 book

KILLING OUR OWN-The Disaster of America's Experience with Atomic Radiation" by Harvey Wasserman & Norman Solomon.

Dr.Manusco started studying the potential health effects of work in the nuclear facilities at Oak Ridge, Tennessee; Savannah River, South Carolina; Los Alamos, New Mexico; and Hanford, Washington. His analysis started from the data emnating from mid 40s'.

In 1974, a study by Dr.Samuel Milham,an epidemiologist at the Washington State Department of Health noticed a ***25 percent cancer excess among Hanford nuclear workers when compared with the rates among the state's non-nuclear workers. Milham*** also found four cases of multiple myeloma, when less than one would normally be expected. [Samuel Milham, Jr., "Increased Cancer Mortality Among Male Employees of the Atomic Energy Commission, Hanford Facility, Washington, June,1974," unpublished manuscript.] It was the same disease found among GIs who first went into Hiroshima and Nagasaki after the bombings.

Dr.Manusco's contract officer from the AEC asked him to issue a statement to counter Dr.Milham's findings. Dr.Manusco declined to do this. From then on his funding was gradually cut and he was eventually asked to submit all his data to the Federal Government in 1977.

Meanwhile the AEC commissioned Battelle Northwest, a think tank with extensive Hanford contracts, to reassess Milham's findings. According to AEC records, the study found precisely what the government did not want to hear- "***that there is a relationship between cancer as a cause of death and the total dose of external radiation received."*** [Draft AEC Memorandum, from Alex Fremling, AEC Director of the Hanford Research Laboratory, July 17, 1975] Alex Fremling, manager of the Hanford Research Lab, lamented that "the message is clear that Battelle's data suggests that Hanford has a higher proportion of cancer deaths for those under 65 than the U.S." But, Fremling continued, "***even more disturbing from our standpoint" was the fact that "the analysis tends to show a much higher incidence of certain types of cancer***" even ***among those exposed to levels of radiation believed to be "safe."*** Thus, Fremling concluded, "we hoped to get a good answer to the Milham report, and instead it looks like we have confirmed it."[ibid.] The Battelle study was quickly buried.

But Thomas Mancuso persisted. In the wake of the Milham affair he turned to Dr. Alice Stewart, the internationally recognized British X-ray researcher and a member of his advisory committee. With the help of statistician George Kneale, Stewart carefully examined Mancuso's data at their office at England's University of Birmingham. ***In the summer of 1976 they showed definitively that there were indications of 5 to 7 percent excess in radiation cancer deaths among Hanford workers at exposure levels as much as thirty times {below} what had been considered safe. The*** Mancuso-Stewart-Kneale findings were shattering not only to the industry, but to public perceptions of what might be a safe dose of radiation from reactors, bomb tests, or a nuclear war. As described by the 1980 {Encyclopedia Britannica, Karl Z. Morgan, "The Hazards of Low-Level Radiation,"} the survey had become ***"the largest study of a normal adult population exposed to low-levels of ionizing radiation" in the world.*** Because it was a largely homogeneous sample of relatively healthy white males whose exposure and health histories had been carefully recorded, there was little reason to doubt its conclusions. And the study had shown, quite simply, that human beings were up to thirty times more sensitive to radiation-induced cancer than previously believed.

The Sellafield Leukemia Cluster

In 1983, a group of children living in and around the Sellafield (Windscale) Spent Fuel Reprocessing Plant (of England) was found to be suffering from Leukemia; this was discovered by the Yorkshire TV, and was eventually telecasted in a programme called, *"Windscale: the Nuclear Laundry"*. This led to the Black Committee, whose report recommended that the Government set up a Committee on Medical Aspects of Radiation in the Environment (COMARE) and the Small Area Health Statistics Unit (SAHSU). SAHSU was set up to ensure that in future clusters of disease

would be discovered by official agencies rather than by reporters and campaigners. They have instead concentrated on developing and propagating methods of dismissing clusters as random occurrences.

However, in the last fifteen years, such clusters of Leukemia have been confirmed in the vicinity of three Reprocessing Plants namely: Sellafield, Dounreay (both of UK), and La Hague (of France). The 0-4 age group of children living in the vicinity of these plants were confirmed to be living with a Relative Risk ranging from 8 to 15. In addition, child leukemia incidence clusters have been confirmed at the Atomic Weapons Establishment (AWE) at Aldermaston and Burghfield in West Berkshire of UK. **Excess leukemia risk** has also been reported **near nuclear power stations in the UK** (Cook-Mozzafari P.J, Darby,SC. Doll R, Forman D, Hermon C, Pike MC, Vincent T (1989) "Geographical variation mortality from leukemia and other cancers in England and Wales in relation to proximity to nuclear installations 1969-78" *Br.J.Cancer* 59: 476-85), **in Germany** [Hoffmann W., Greser E.(1998), "Epidemiologic evaluation of leukemia incidence in children and adults in the vicinity of the nuclear power plant Kruemmel(KKK)"in Schmitz-Feuerhake I and Schmidt MM, *Radiation Exposures by Nuclear Facilities, Proceedings of an International Workshop, Gessellschaft fuer Strahlenschutz, Portsmouth, England 1996* (Bremen:Gessellschaft fuer Strahlenschutz)] **and in Sweden** [Andersen H, Moeller T, (1997) "Cancerinsidens omkring Barsebaecks Kaernkraftwerk" Lund: Regionala Tumoerregistret Universitetssjukhuset] (all quoted from: Chris Busby et al., *Cancer Mortality and Proximity to Oldbury Nuclear Power Station in Gloucestershire, 1995-1999,* Green Audit, April 2001).

Cancer incidence among the workers of Nuclear Industry and their Children

Apart from the above findings, there are many studies in the Epidemiology of various types of Cancers among the Radiation/Non-Radiation Workers of the Nuclear Power plants. They deal with the following questions: What is the share of the various types of cancers in causing death to these workers? What are the most common types Cancers seen among them? What is the relationship of the Dose of Radiation they receive during their work to the occurrence of these malignancies in them? How much are their children affected by various types of cancers? Is there any relationship between the dose of Radiation these workers receive prior to conception and the subsequent occurrence of malignancies among their children?

All these studies confirm that there is a significant excess of leukemia and non-Hodgkin's lymphoma at ages 0-24 in those who were born in the vicinity of nuclear reactors. (Kinlen L.J et al., 'Can parental preconceptional radiation account for the increase of leukemia and non-Hodgkin's lymphoma in Seascale?, BMJ, 1993, Jun 26;306(6894):1718-21).Draper et al., found a 1.8 fold excess relative risk for leukemia in children of male radiation workers and a 5 fold relative risk in children of female workers ("Cancer in the offspring of radiation workers: a record linkage study", BMJ,1997; 315:1181-1188(8 Nov). Roman et al., found a 2.2- fold excess risk of leukemia in the children of radiation workers in west Berkshire. ("Case-control study of leukaemia and non-Hodgkin's lymphoma among children aged 0-4 years living in west Berkshire and north Hampshire health districts". *BMJ 1993; 306: 615-621). Lopez-Abente* et al., have reported that there is an excess risk of multiple myeloma mortality among the people living in the vicinity of the Zorita nuclear power plant of Spain. (Cancer Epidemiol Biomarkers Prev 1999 Oct;8(10):925-34).

All the studies dealing with the share of Cancers among all the causes of Mortality in the workers who have worked either in the nuclear power plants or in the nuclear weapons factories have come to one conclusion: that the Mortality among them was LOWER than the national average for all causes of death; the mortality from cancers of all kinds was LESS than that of the country's average for mortality due to all types of cancers; ***BUT the mortality due to certain specific types of cancers was very high among them;*** Thus, Beral et al.,("Mortality of employ-

ees of the United Kingdom Atomic Energy Authority, 1946-1979", BMJ (Clin Res Ed) 1985 Aug 17; 291(6493):440-7) tells us that mortality due to Testicular Cancer, Leukemia, Thyroid Cancer, and non-Hodgkin's Lymphoma was above the UK national average. The mortality due to Prostate Cancer was also higher than the national average(ibid). Smith PG et al.,("Mortality of Workers at the Sellafield plant of British Nuclear Fuels (1947-1975)", BMJ (Clin Res Ed) 1986 Oct 4; 293 (6551): 845-54) tell us that, compared to the general population, there was an excess of deaths from Multiple Myeloma, Prostatic Cancer among the Radiation workers; Non-Radiation workers showed a significant excess of cancers of ill defined and secondary sites.

What do all these studies tell us?

They inform us to expect that the workers at the Kalpakkam nuclear complex, their children, and the people living within a radius of 5-10 km might also be suffering from an increased risk to cancers like Leukemia, Prostate Cancer, Multiple Myeloma, Thyroid cancers, Renal cancers and cancers which are ill defined and at secondary sites.

Incidentally we have noted from the data given in the EIA that the levels of Cesium, and Tritium are gradually increasing in the regional environment. We have also noted that the emissions from the MAPS reactor is fluctuating dramatically year by year, and that it is on the increase in general.

All these data force us to ask one basic question. Why didn't the Mecon EIA study the relationship between the disease pattern of the area and the routine radioactive discharge from the nuclear plants of the Kalpakkam Nuclear Complex? Shouldn't this be one of the very basic analysis that the EIA should have attempted (at least) while writing the EIA?

Actually, a Cancer Screening study has been attempted for the employees and their families of the Kalpakkam Reactor Complex in 1997-98. This was conducted by the Govt.Aringar Anna Memorial Cancer Research Institute of Kanchipuram on behalf of the Tata Memorial Centre, Mumbai.Why the MECON EIA has not mentioned even a single word about this study in its report? *How can the TNPCB accept such an impact assessment study, which has turned a blind eye on one of the most important impacts of the reactors already present, as a scientific one?*

So, here we have an EIA that does not want to have a knowledge of the health and the disease profile of the region's population but still has the temerity (in the name of Science!) to tell us that no harm will be done to the people of the region by the proposed nuclear plant!!!

Chapter 9
Can the People of the Region cope with another Nuclear Power Reactor biologically?

How to answer this question when we do not know their Health and Disease Profile? Still, we do know the types of nuclear activity going on in this area, and also we do have a basic understanding of the dynamics of its environment. With this understanding, and with the studies conducted in the similar environments with similar nuclear reactors elsewhere in the world, we may attempt to provide a hypothetical answer to this question. ***Any attempt to construct a reactor in this area should first of all disprove this hypothesis objectively.***

This is a site located on the Eastern Sea Coast of Tamil Nadu. This sea (the Bay of Bengal) has a predominant northerly current during the SW monsoon (June-Sep), and a southerly current during the NE monsoon (Oct-Dec). In October and February the currents are very weak. These long shore currents transport large quantities of sediments during their movement. The tides of this sea are semi-diurnal in their occurrence (that is, having two highs and two lows everyday) [*Marine Protected Area Needs in the South Asian Seas Region,Vol-2:India,* ed., John C.Pernetta, IUCN, 1993] ; the mean Tidal range may be around +0.4 to +0.45 meters for this coastal region. (It is +0.34m for Nagapattinam and +0.59m for Chennai, and so the value for this region should be somewhere in between) [Sambasiva Rao M., in *Sea Level Variation and its impact on Coastal Environment,* ed., Victor Rajamanickam, Aug'1990, p-288].This Region has salt affected areas and coastal low lands. (ibid,p-184). There are tidal mud flats and marshy areas in the backwater zone between Kokkilamedu and Kunnathur-Manamai area.(p,4-4, EIA).There are two estuaries located to the south of the Kalpakkam Nuclear Complex Site - one is the mouth of Palar River at Oyyalikuppam and south (~8 to 10 KM south), and the mouth of a small creek called Kaluvalur River at Sadras and south (~8 to 6 KM south).Backwaters are found east of Kokkilamedu and Manamai, and south of Pudupattinam Colony.

Rainfall is high from July to December; it reaches its peak in the months of October and November (274.9 to 363.9mm). It is generally low from January to June; the lowest rainfall occurs in the months of March and April (5.4 to 6.7mm). Thus we see the regional rainfall fluctuating at around 50 times the lowest value every year (inferred from the rainfall data for the period 1968-1995 presented in the EIA, p-4-22). An analysis of the rainfall frequency for the period 1971 to 1998 at the Mahabalipuram rainfall station shows that the rainfall was regular during 57% of the analysed period. The region was drought prone in some degree of severity during 43% of the period analysed. The region faced severe droughts in the years 1997&1998. In addition to this there were mild droughts for 8 years (1973,1980,1981,1986,1987,1988,1989,1992), and moderate droughts in the years 1974 and 1982.

The surface water was tested for its quality by the scientists of the EIA at 10 sites. Chlorides and Sulpates were found to be in excess in waters near Perumalchery, Meyyur, east of Kilakalani and Pavakarachathiram. Similarly Ground Water's quality was tested in 10 sites; out of which,the water at Kunnathur and Ayapakkam was found to be alkaline;Total Dissolved Solids (TDS) was increased in the water of Kadampadi and Kulipantandalam. Iron content was very high in the water tested east of Kuttavakkam.

The site experiences a Southerly wind (blowing from south to north) at 30m and 60 meters height for the period between April to September. It is also experiencing a South South Easterly wind blowing into the land from the sea in the periods April to June. A predominant North Easterly wind blows in the period Oct-December, and January to March. An Easterly wind is blowing in the monthly period of January to March. A Westerly wind is experienced in the July-September monthly period. The usual predominant wind speed is 12 to 19 km/hour.(p,4-14,EIA). Hence we should consider the land areas falling in the sectors A,B,G and H as the predominant Down Wind areas. (See map for locating these sectors.)

The ground contours vary between 5.49m and 13.41 m (above mean sea level) between the sea in the east and the Buckingham canal in the west. The soil type is sandy, silty and clayey along the beach, Buckingham Canal and the Backwaters.(p,4-2,EIA).The Cationic Exchange Capacity of the soil (which has a positive bearing on the transportation of Radionuclides in the Soil) is found to be high in the areas around Manamai. (p,4-11,EIA).

The whole region is dotted with many Irrigation Tanks. Many of them are located in the above said Down Wind directions. The EIA notes that the area covered by water bodies (meaning- tanks, ponds and backwaters) in the 16 sq.km zone surrounding the Kalpakkam Nuclear Complex is 13.4% of the total land area of the zone. (p,4-85).

The paddy fields cover 14 to 15% of the above said zone. Other crops like maize, ragi,pulses and groundnut cover around 10.5% of the land area. Plantation crops like banana, mango, coconut, palm and sugarcane cover an area of 10-13%. Forest cover is 5-8%. Barren land and wasteland vegetation account for another 33.5%. Sand found in the beach and Palar River bed account for 7% of the remaining area. (p4-85, EIA).

According to the 1991 census, the population living within 0.5 to 3km radius was 3,750; within 3 to 7 km radius was 37,613; and within 7 to 20 km radius was 2,28,883. That is 2,70,246 persons living within a radius of 20 km from the site. This is around 2,63,215 persons for the year 2001 (calculated at 15% population growth over the past decade).

About 85% of the population derive their livelihood from agriculture. 35.4% of this group are Marginal Farmers (with landholding <2.5acres). 25% are small farmers(2.5 to 5 acres). Medium Farmers (5-10 acres) are about 15%.Large farmers (>10 acres) form around 10%. Landless agricultural labourers form around 14.5%.

Out of this prospected population (for 2001) of 2,63,215 persons 1,23,343 are women.

The number of villages and settlements in the 16 km zone is approximately around 140; Out of these villages, we notice that around 75 villages are clustered in the south. The number of villages and settlements located within 1 km from the shoreline is around 18; Out of these 18 villages and settlements, 11 are located south of the nuclear complex and the remaining 7 are present in the north shoreline. Out of these 18 coastal villages and settlements the DAE Quarters, Pudupattinam Colony, Sadras and Mahabalipuram boast populations more than 5,000.

Any discharge of radioactive liquid or gaseous wastes from the reactors of the Kalpakkam complex are bound to get dispersed into the regional environment through the above said factors of wind, rain, surface water, ocean currents and tides. The places that will be most affected will be those that are located in the downwind directions and those in which the sediment from the ocean will be deposited by the ocean currents and tides. The rainy, windy months shall see the radioactive Iodine, Cesium, Strontium and the noble gases released through the stacks spread to a very wide area and get settled on the land and surface water around, thus making them enter the food chain of the area. The period of low tides combined with a dry weather shall see an increase in the radioactivity emnating from the exposed sediments deposited by the currents and tides.

As said above, the places that should always be on alert shall be the down wind zones which shall be experiencing a rainfall along with the winds. They will be the sectors that are located in the South and South West directions (sectors I,H and G) to the Kalpakkam Nuclear Complex. In the

same way, the places that should always keep an eye on the radioactivity released from the sediments deposited by the ocean currents will be those villages and settlements located on the shore within around 5-10 km from Kalpakkam, and those that are located on the backwaters within this distance; the villages that are located within 1 km from the sea in this 5-10 km area should be more careful about this route of radionuclide transport from kalpakkam.

With this in mind, we shall now go through the health impact studies that have been conducted for the nuclear power plants located on the sea coast, elsewhere in the world.

There are four studies. Three have been done in the UK and one in France.

The studies in the U.K. were done by Chris Busby, Paul Dorfman and Helen Rowe of Green Audit. The French study was conducted by J.F.Viel et al. of the Dept. of Public Health, Faculty of Medicine, Besancon, France.

The three nuclear power plants studied in the UK[1] were: Hinkley Point Power Station, Oldbury Nuclear Power Station in Gloucestershire, and the Bradwell Nuclear Power Station in Essex. The French study was for the areas surrounding the La Hague Nuclear Waste Reprocessing Plant.

All the four studies concluded that the rad waste releases from the nuclear power plants contaminate the coastline and the banks of the rivers near their mouths. In the cases of Hinkley Point and that of the Bradwell in Essex, the areas off intertidal sediment could be predicted easily, and the populations of small towns closest to contaminated mud showed highest risk to various types of cancers. In some towns (like the Burnham on Sea and Maldon) the Breast Cancer Risk was about twice the national average.

In the case of Oldbury Nuclear Power Station, the study concluded: "1) With the exception of Prostate Cancer, there was statistically significant increased risk for all the cancer mortality studied in the coastal areas within 5 km from the sea below the Severn Bridge where there is a great amount of radioactivity contaminated coastal or estuarine sediment. 2) There was a significant child leukemia cluster in the town of Chepstow, which is on a tidal estuary and within 10 km of the Oldbury nuclear power station. The strength of this finding is comparable to that of the Sellafield leukemia cluster at Seascale. 3) There was a modest, but statistically significant Prostate Cancer excess within 7.5 km of Oldbury nuclear site, but no other cancers showed excess within this radius, suggesting that it may be a nuclear worker effect. 4) Cancer mortality seemed higher close to river valleys, particularly for lung cancer. This finding also occurred in earlier studies (at Hinkley Point and Bradwell in Essex). These findings confirm the prior hypothesis that the radioactive releases from the Nuclear sites and sources which discharge to sea or to rivers result in the exposure of the people to the contaminated intertidal sediment which in turn causes an increase in Cancers among them.

The 16 yearlong French study conducted in the area around the La Hague Reprocessing Plant (Viel, J.F and Poubel, Dominique, (1997), 'Case Control Study of Leukemia among young people near the La Hague reprocessing plant: the environmental hypothesis revisited.' British Medical Journal 14: 101-6) concluded that, there is an association between the pregnant women and children going to the beach around the La Hague plant more than once a month and the consumption of local seafood by children and an increased leukemia risk among them.

What do these studies tell us?

They tell us that such an increased risk to various types of Cancers is a high possibility for the population living around the Kalpakkam Nuclear Complex.

Till recently it was thought that Low Level Radiation emnating from the low level rad wastes released into the environment by the Nuclear Power Plants can never be harmful to the Health of the population living around. These studies have proved now that this assumption held by us is not true.

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[1] *Chris Busby et al., Cancer Mortality and Proximity to Oldbury Nuclear Power Station in Gloucestershire 1995-1999, Occasional Paper 2001/6, Green Audit: Aberystwyth, April 2001*

Chris Busby et al, Cancer Mortality and Proximity to Bradwell Nuclear Power Station in Essex, 1995-1999, Green Audit: Aberystwyth, March 2001

Chris Busby et al, Cancer Mortality and Proximity to Hinkley Point Nuclear Power Station 1995-1998, Parts I &II, Green Audit: Aberystwyth, 2000.

This will be more clear when we look at the findings of the study on the Hinkley Nuclear Power Station.

"In 1989, NRPB (National Radiological Protection Board) published the results of their study into Gamma Ray backgrounds in England and Wales. (***Gamma Radiation Levels Outdoors in Great Britain*** **- NRPB R191).**

Using the tables and maps given by NRPB it was possible to compare areas of England and Wales on a 10km grid. This showed that average gamma background inland over the study area was 34nGy/hr (over a year, this represents about 0.3mGy or a fifth of the average Natural Background). But comparable gamma figures were also available from the reports of the operators of the Hinkley Point nuclear power station. These gave gamma dose rates over the mud near the site at upward of 100nGy/hr. Also tabulated in these reports were figures for Burnham beach and nearby Combwich beach of 60 and 80nGy/hr. Why do the beaches confer twice to three times the gamma dose? Because they contain most of the accumulated radioactive waste discharged to the sea by the plant since its commissioning. This material attaches to the silt and is blown ashore with sea spray. It is rained out over Somerset and washes into the rivers where it re-joins the silt in a dangerous cycle ***resulting in increased risk of exposure to those living near the sea, the tidal sediment and the tidal rivers."***

"Radioisotopes come ashore in a number of ways ***and exposure is through inhalation of dust or sea spray and ingestion of contaminated food, water or milk***. Recently Viel (Viel, J.F and Poubel, Dominique, (1997), 'Case Control Study of Leukemia among young people near the La Hague reprocessing plant: the environmental hypothesis revisited.' British Medical Journal 14: 101-6) showed that the two main excess-risk factors associated with childhood leukemia in his case-control study of the population near the La Hague reprocessing plant were playing on the beach and eating shellfish. Proximity of a population to an estuary area where there is a large expanse of sand has also been shown to carry excess risk for childhood leukemia by Alexander (Alexander, F.E, Cartwright, R.A, Mac Kinnon, P and Ricketts, T.J, Leukemia incidence, social class and estuaries: an ecological analysis. Journal of Public health medicine, 12, 109-117, (1990)] In a recent analysis of the leukemia clusters near the weapons facilities in Newbury, Busby has drawn attention to high concentrations of radioactivity on dust particles trapped in passive filters and has suggested that the movement and distribution of small radioactive particles may be influenced by the electrostatic charge acquired by them as they decay and the way in which these micron sized charged dust particles are affected by the earth's electrostatic field. (Busby Chris, (1998a), Childhood leukemia and radioactive pollution from the Atomic Weapons facilities at Aldermaston and Burghfield in West Berkshire: Causation and Mechanisms. Occasional Paper 98/1, Aberystwyth: Green Audit). Positively charged particles resulting from beta-particle emission would be attracted to the ground whilst negatively charged particles, e.g.plutonium oxide, would be repelled and driven into the air , to be blown ashore and collect and concentrate at electrostatic singularities."

"In addition to the discharge to sea to person route hypothesised above there is , in the case of Hinkley, the direct exposure route in those populations living immediately downwind of the aerial discharge stacks. Thus we would predict a priori that the inhabitants of Burnham on Sea would be at risk following exposure to aerial emissions of Tritium, Carbon-14, noble reactor gases etc. In general, the releases from Hinkley Point would be expected to result in increased levels of radioisotopic contamination in the river valleys also, since the rivers in the area are tidal for a considerable fraction of their length. In addition, any aerial discharges would result in deposition in the basin defined by the Mendip and Quantock Hills and deposited radioactive material will be washed back into the rivers by rain. Thus we would expect a higher risk of cancer in the lowland areas near the rivers, an expectation which was supported by the earlier results for breast and prostate cancer."

The idea that low level radiation does not cause any significant cancer risk to the population exposed to it has its base on the studies conducted in the atom bomb survivors of Nagasaki and Hiroshima. This method of explaining the health effects of low level radiation using the data of atom bomb survivors can not be accepted. Let us see the reasons as to why we can not accept this.

Richard Bramhall, of Low Level Radiation Campaign (llrc)of UK, in his address to a Welsh Antinuclear Alliance meeting in Chepstow, Wales, on 23rd February 2001 explains:

"The official risk agencies understand ***radiation dose*** as energy transfer averaged over substantial volumes of tissue. They think in terms of whole organs, the whole body, or even entire populations - as in the case of the collective doses from Chernobyl and NRPB's leukaemia predictions. But there is no doubt that the vital target for radiation damage is not the whole body but individual cells. This is admitted by the radiation protection community. Roger Clarke, Chairman of ICRP and Director of NRPB, has written:

"there is compelling evidence that cellular DNA present in the chromosomes of the cell nucleus acts as the principal target for spontaneously arising and carcinogen-induced tumors in humans and experimental animals. ... At present the evidence available supports the view that ionising radiation acts most strongly as the early initiating phase of tumour development by inducing specific gene loss in stem cells.

DNA damage comes from discrete radiation tracks, and cells are either hit or are missed altogether (for the time being we'll ignore the newly discovered and poorly understood "bystander effects")

So the important effects are happening at the level of the individual cell, and we should remember that cancers are "monoclonal" - that is, if you do DNA analysis of cancerous tissue you find that all the cells are descended from a single mutated cell.

If you grasp the idea that it's at the cellular level, rather than the whole body level, that NRPB's averaging model breaks down it's much easier to visualise. (and for practical epidemiological purposes you could regard the entire human population of any given study area as one vast colony of cells.)

So where environmental contamination at low dose is concerned the real situation is not, as NRPB's model assumes, that whole body doses cannot vary much, so "No problem". What is really happening is that hot particles, or individual atoms of nuclides which decay sequentially, are causing huge local inhomogeneities of dose. Like the armed madman shooting at the crowd in the supermarket; he hits me; he misses you.

This is why depleted Uranium is such an important issue. The tiny glassy beads of Uranium oxide created by DU (Depleted Uranium) weapons float around in the air, are easily inhaled, and migrate to the lymph nodes, where they stay. It's not just us that says this - look at what one of the world's most important radiation biologists says about it:

Burning uranium forms small particles of uranium oxides, between 0.1 and 10 microns wide, which can be inhaled. White blood cells scavenge the particles in the lungs and deposit them in the tracheobronchial lymph nodes. They are highly insoluble, and might not show up at all in urine, while still emitting intense local alpha and beta radiation. That could damage blood stem cells, causing leukaemia.

This is quoted in *New Scientist* and it is completely out of step with what NRPB says - they take no account of these very "intense" local effects. How did this situation arise?

Well, it's because their understanding of hazard is based on studies of Hiroshima survivors - these studies are *pivotal*, NRPB says. The *survivors* were people who were in the open when the bomb went off. So they were exposed to a single massive flash of gamma rays delivered from outside their bodies and evenly spread. The whole of their bodies would have got much the same amount - just think of a camera flash gun - it lights up everything in front of it!

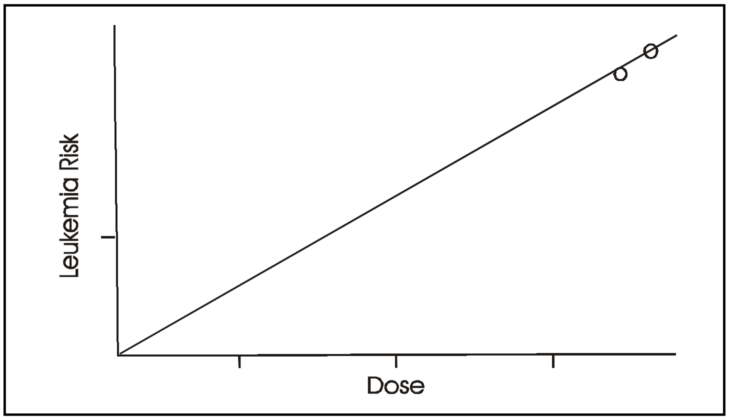
So, right from the start, you have a type of exposure which tells you nothing about the local effects of internal contamination.

Then, *as "science"*, it gets worse. To find out the effects of any type of influence or exposure you have to compare rates of disease in the "exposed" people with rates in an "unexposed", "control" group. The controls for Hiroshima were people who had been out of the city when the bomb exploded, or were sheltered underground or behind thick walls.

But both groups lived in the city, and were equally exposed to eating, drinking, and inhaling fallout, so the "controls" were equally contaminated. ALL the studies of the Japanese survivors are based on the same "exposed" and "control" groups. So NONE can ever tell ANYTHING about internal fallout.

But NRPB aren't too bothered about that.

Here's what they do.



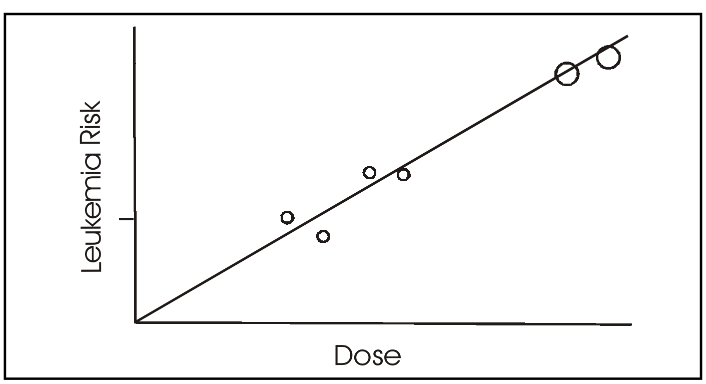
Going up the vertical axis we see increasing genetic damage; going left to right along the bottom is increasing dose.

This is the famous Linear No Threshold model - damage is strictly proportional to "dose" or "energy deposition"; and there is no dose too small to do some damage - in theory. But there are only two data points - the very high gamma doses at Hiroshima caused some leukaemia - and the line between those points and the "origin" - zero dose and no extra damage - is just an assumption. A guess. Professor Goodhead, who was quoted in the New Scientist slide I showed earlier, calls it a large area of uncertainty.

And just to confirm it, here's what the top man at NRPB says:

"***In the absence of directly informative data ... the shape of the low-dose response has to be judged on indirect data on the cellular mechanisms involved in the whole of this complex process".***(Roger Clarke, Chairman of International Commission on Radiological Protection and Director of National Radiological Protection Board Control of low-level radiation exposure: time for a change? J. Radiol. Prot. Vol. 19 No 2 107 - 115)

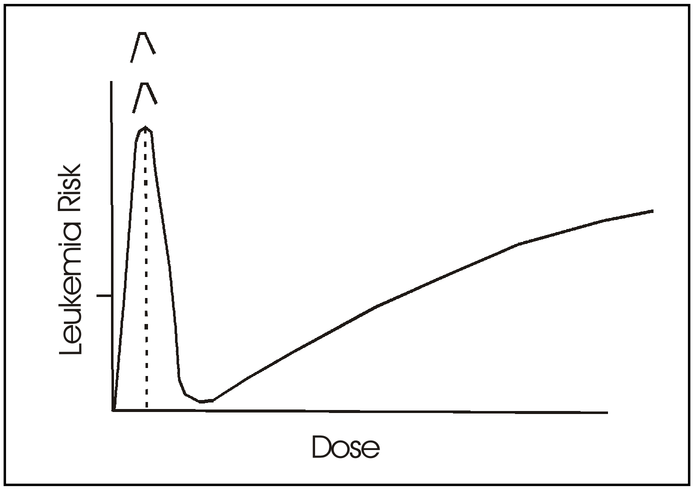
NRPB is fond of saying that the straight line is supported by other studies. You can represent them with some extra dots on the graph, like this:



But these again are relatively high doses of external radiation, so the problem remains - it's

guesswork at low dose. What is the reality?

A substantial number of studies have been put together and show a curve like this:

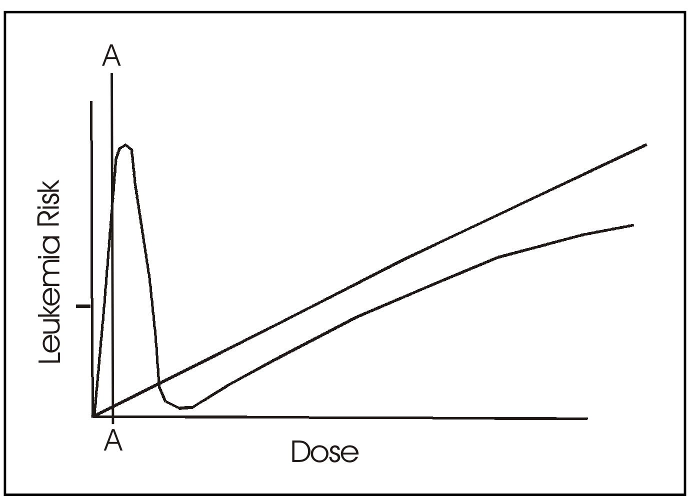


Now you can see that in the very low dose region, on the left hand side (that's what we are concerned with in environmental pollution) genetic damage increases rapidly as sensitive cells are hit and mutated.

As dose increases a bit more the effect peaks, and begins to fall off. This is because the sensitive cells are being killed, rather than being mutated. Just as dead men tell no tales, dead cells don't multiply to become cancers.

As dose increases a bit more, the insensitive cells begin to be mutated, so that's why the curve begins to rise again. Note that this second upward slope parallels the LNT line - NRPB seems to have got it about right at these higher doses.

Eventually there would be a second falling off - but that represents the death of whole organisms (I mean "people") from acute radiation. That's at very high doses, but it's the very low doses on the left-hand side that interest us, and now we can see why there is such a huge error.



At any level of dose - A - A for example - the size of NRPB's error is the distance between the straight "LNT" line and the wavy "biphasic" curve, compared with the distance between the LNT line and the bottom of the graph. That could easily be 100 fold.

What we have to note is that at higher doses the two curves agree.

External Radiation Levels within Kalpakkam Site

(p,4-78, EIA) [External Radiation in nGy/Hour (1998)]

Ref No	Location	Maximum	Minimum	Average
1	HASL Portico	150	80	108
2	WSCL	150	80	92
3	MSL(PSF)	140	100	118.7
4	CDO Portico	150	100	113.8
5	FBTR Security	150	80	89.6
6	CWS Behind (53)	150	100	122.9
7	CWMF Portico	200	100	145.8
8	CWMF (SWMB) Portico	550	120	202.9
9	End of Trench	530	150	239.3
10	IGCAR Gate	230	100	149.1
11	Kokilamdu Gate (Security Room)	200	150	177.8
12	Kokilamedu Gate (Area Monitor)	220	170	202.4
13	Kokilamedu Gate TLD	270	220	240
14	Post No 250 (On Way to KKM)	150	80	102.9
15	Post No 212 (On Way to KKM)	330	200	280.4
16	PRP Gate	600	120	198.4
17	MAPS Gate	650	120	209.1
18	Main Gate (Area Monitor)	380	280	337.1
19	Main Gate	400	300	310.9
20	Main Gate TLD Location	670	570	605.8
21	Old MM Lab -PFBR Site	650	300	419.1
22	WIP (Near Monitering STn)	700	120	200.7
23	KARP Portico	330	100	140.7
24	RDL Gate	550	100	165.1
25	RCL Portico	280	100	122.7
26	CWCP Portico	250	80	112.7
27	CWCP Steel Yard	250	100	118
29	CWCP TLD Location	300	80	104.4

The practical implication of this is that a lot of research is needed to identify which isotopes, and which physical and chemical forms of them, confer the biggest hazards [it's possible that some forms of nuclear pollution are no more dangerous dose for dose than Natural Background Radiation]. Only then can we develop rational and scientific standards for dealing with the legacy of radioactive junk the industry has bequeathed us."

It is an irony that in the Kalpakkam region, the people who might have been affected the most already might be the scientists, engineers and their family members who are residing in the DAE Quarters. Their's is also the largest settlement present within the 8km zone.

The DAE Quarters is located in the worst possible place. It is at around 61/2 KM south of the Kalpakkam nuclear complex; and so, it is in the Downwind direction; Not only that....it is located on the banks of the Kaluvalur creek, and hence in the months of October and November when it rains almost 15-20 days a month, the radionuclides that get settled over the land around Velangadu and Kudiperambakkam in the west, shall be washed by the water flowing in the creek and shall be deposited on its banks over which the quarters is located. If this is the contribution by the rain, the sea also shall be contributing an additional amount of radionuclides to the township in this same season. The longshore current in the sea during Oct-Dec' is in the South West direction. This will carry the radionuclides let out by the reactor complex at Kalpakkam and the tides in the sea shall carry them into the Kaluvalur creek and deposit them. The tides seem to go up to Perumalchery, and this is demonstrated by the excess of Chlorides and Sulphates (4-6 times the permissible value) in its surface water. In fact this water was tested in the months of September and October' 1999 by none other than the Mecon scientists! [The EIA even notes this when it states 'these locations are affected by seawater during high tides (p,4-32, EIA)]. It would really be tragic here to recall that it is in a similar spot, the small towns of Burnham on sea and Meldon were located with respect to the Hinkley Point Nuclear Reactor. It is in these towns the Chris Busby study found the incidence of Breast cancer to be twice the national average.

The tragedy does not end there; as these scientists are bound to go to work in the Kalpakkam Nuclear Complex, they shall be exposed to a constant low dose radiation in their workplace itself on a daily basis [which is far more than the amount of radiation that the mud flat near the Burnham on sea was emitting (100nGy/Hr)]. Let us now see the amount of radiation emitted by their workplace. (see the Table previous page)

The Table tells us that on an average (even though averaging in this instance is not correct here) the whole Kalpakkam Site is emitting a constant low dose radiation of 194 nGray/Hour every day, thus bathing the poor scientists and engineers working there everyday.

Apart from this, I feel it is here that I should mention a very disturbing statement given in the EIA.

"The solid waste generation in fast breeder reactors is in general reported to be lower than in light water reactors...Boxes are provided in shielded rooms for solid waste collection and temporary storage. High active Wastes are stored in flasks and shielded cells before loading them in containers for transport to CWMF....The impact of these operations in the public domain is insignificant. ***The only indirect impact anticipated is due to leaching from storage locations and coming into contact with the ground water. The design of the storage locations is such that the possibility of leakage of the radioactivity is extremely unlikely. <u>Should such an incident occur, the ground water contour in the locality is such, the contaminated ground water flows only towards the sea resulting in no impact to the public.</u>****"*

This incidence if it occurs during the months of October to January, the people living in Meyyur,

Sadras, DAE Quarters, Oyalikuppam,Chinnakuppam, Periyakuppam, Nikuppam WILL be affected

severely as the radioactive wastes will be carried south by the south west bound longshore current; along these villages and settlements, the villages located on the banks of Palar River like Anjukani, Tudandarpettai, Kedalur, Veppancheri and the villages located on the banks of the Kaluvalur creek like Perumalcheri and Vittalapuram will also be affected.If this accident occurs in the months of July to September then it is Mahabalipuram that will be affected very severely since the longshore current flows towards northeast during these months; apart from Mahabalipuram, villages like Karayarkuppam,Venpurusamkuppam, and the villages that are located on the backwaters like Venpurusam, Kilakalani will also be affected.

Why did the MECON team make the above statement even when it noted the presence of these currents in the following sentences: "*...The current velocity in this region generally varies between 16.7 to 41.7 cm/s (600 m/h to 1500 m/h).The direction of the current is mainly along the coast, either northward or southward depending on the season and the monsoon." (p,4-4)*

Was that statement made intentionally? Or was it made just because the team didn't have a holistic view of the place they were writing about?

The points that we have noted in this chapter tell us that even today the population living around the Kalpakkam Nuclear Complex is facing a higher risk of contracting to various types of cancers. If another reactor that is going to handle Plutonium is constructed, this risk will increase manifolds; and Plutonium-239, an alpha emitter, having a half-life of 24,100 years and proved by many studies as having a tendency to get transported very much by the sea route shall not only compound this problem but will change the biological makeup of the people and the living beings of this region irreparably.

Chapter 10

Thermal Pollution and other issues

If the risk of Cancer is threatening the people of this region, its marine life is under threat from the Thermal Pollution; this is bound to happen if one more reactor comes up at Kalpakkam. The two MAPS reactors are letting out their hot condenser cooling water in to the sea for the past 15 years; and this they are doing in the most primitive way. They discharge the hot condenser cooling water out on the shore, allowing it to run for some distance; this act, they say, will cool down the water considerably, so that when the water reaches the sea it will not harm the marine life.

A similar setup is proposed for the PFBR Reactor too. The EIA says that "*to meet the requirements of Environmental (Protection) Rules the condenser out-fall will be channelised so that at the point of mixing with the sea water the warm water temperature is not more than 7K above the inlet to the condenser." (p,2-22).*

In another place (p,7-18),the EIA states that, "*It was observed that the temperature of sea water at the intake point would rise by 2.5^{0}C, if the discharge is on the shore just opposite to the intake well. This, however is not happening due to natural channel formation along the coast, which shifts the effective discharge point by 400 m to either side of the outfall from the condenser.* ***In case of no natural channel formation, providing a channel for the effluent discharge may need to be considered.***"

Next, let us take a look at the table giving us the details of the seawater temperatures observed at MAPS power plant.

Date	Temperature in ^{0}C		
	Outfall (200,0)	End of Channel (0,0)	Intake below jetty (200,500)
02-08-99	36.5	32.0	28.5
17-08-99	37.0	32.5	28.0
10-09-99	32.5	32.5	28.0
23-09-99	36.5	31.0	28.5
16-11-99	37.5	35.5	29.5
05-11-00	35.0	32.0	29.5
24-02-00	37.5	34.0	30.5

The Table reveals certain facts. In it we see that the cooling power attributed to natural channel formed on the shore is varying wildly between 0^{0}C to 5.5^{0}C (see the data given for 10-09-99 and 23-09-99). When it will cool the condenser water effectively and when it will not have any effect at all, no one can predict. The confidence placed on such an unreliable method of cooling is thus totally misplaced.

When we look in to the volume of hot water that will be discharged daily, we understand the acuteness of this problem. 1840.32 Lakh Liters of Hot Water shall be released into the sea daily; and the authorities and the MECON team tend to believe that a natural channel will somehow cool this volume of water to a level that is below the prescribed value of the environmental protection rules!!

Supposing this system fails to work (as on 10-09-99 and 16-11-99 of the above table)? It will mean a total decimation of the marine life of the area.

It is said that the proposed PFBR shall be releasing shock doses of Hot Water whenever it shuts down or restarts. During these times, the EIA team itself states, that there will be potential impacts on the marine life (p,5-10).

The point to note down here is that, such an unreliable cooling system for cooling the hot condenser water can not be accepted at the present time. In fact, all the power plants that were constructed in the US after the mid seventies gave up this method of cooling; instead they went in for the more reliable methods of cooling these discharges using cooling towers or cooling ponds.

Hence, the Pollution Control Boards should pressurise the AEC to include such a cooling system for the PFBR.

Reducing Krypton Gas Emission

In the 1980s' most of the nations (especially the UK) involved in nuclear spent fuel reprocessing asked all their reprocessing industries to fit ^{85}Krypton capturing devices. It was actually in 1977, BNFL of the UK., was first instructed to capture krypton by Mr. Justice Parker at the original inquiry into Thorp.^{85} Krypton is a noble gas and a beta emitter and is released in large quantities by reprocessing plants.

It is stated that the emission rate of ^{85}Kr from the PFBR will be 6.10E+13 Bq/annum which is comparable to the emission rates of ^{3}H(6.03E+13Bq/a) and ^{135}Xe(6.23E+15Bq/a).(p,5-24). Hence, the Pollution Control Board should make it a point to press the AEC to fit a ^{85}Kr capturing device to the PFBR. Similarly, the TamilNadu Government should ask the Kalpakkam Fuel Reprocessing Plant (KARP) to fit a ^{85}Kr capturing device immediately.

Chapter 11

The Weakest Link in the PFBR Programme

FreshWater seems to be the Weakest Link in the PFBR programme.

The PFBR uses Liquid Sodium as its coolant. Other conventional nuclear reactors use Heavy Water or Light (Ordinary) Water as their coolants. Still, the role played by fresh water in a Fast Breeder Reactor is immense.

Fresh Water is used for many important activities (in the Fast Breeders) that have a direct bearing on the Safety of the Reactor.

There are four main purposes for which Fresh Water is used in a Fast Breeder. They are: 1) Supply of water for the Steam Generator Loop, 2) Cooling purposes which include cooling the spent fuel, roof slab, for the use in biological cooling system, and chilled water system, 3) Decontamination and 4) Fire Fighting.

Fresh Water is required by all of the above purposes on a fail-safe basis. The volume of water needed will be 15.31 Lakh Liters/Day. If water is not available even for one day, all the works that involve the act of Cooling will get stopped and the concerned units will start getting heated up; this, if not stopped immediately, will precipitate an accident.

It is for this reason, the PFBR is going to get a special Fresh Water Reservoir for its own use. This Reservoir will be constructed near the PFBR site itself. Its capacity will be around 190 Lakh Liters. The Water from this Reservoir will be enough for looking after the Reactor for 7 effective full Power days, in case there is a short supply from the headworks.

In addition to this Reservoir an underground tank of 40 Lakh Liters will also be built, and this shall receive its water supply from the Reservoir. Out of this 40 Lakh Liters, 23 Lakh Liters is reserved for the purpose of Fire Fighting. The remaining Water will be used for the remaining three purposes.

Apart from the above arrangements, special extra provisions are also made for each unit that require the use of Fresh Water; so, in case, the water supply from the Reservoir and the Storage Tanks are also cut, then these special provisions built into these units will takeover, and keep the Units cool for a short while. This is around 4.7 days for Spent Fuel Cooling and 8 hours for Roof Slab Cooling.

From where will this water be drawn and what is the hydrological potential of the headworks?

The water will be drawn from an intake well present on the Palar River bed that is located near Panankattucheri. This is 16 km south-west of Kalpakkam. It is from here that the 2 MAPS Reactors are also drawing water for their needs. The headworks will be operated by the TamilNadu Ground Water Board.

Can this headworks supply the required Water every day, without fail, for the next 45 years?

It is this question, which obviously is one of the most important ones that has a direct bearing on the reactor safety, that the MECON EIA has chosen to ignore. The EIA report has neither raised this question nor has bothered to analyse the hydrological potential of the area.

Still, we shall take this task ourselves and do the analysis.

Panankattuchery is located in the Lathur Block of the Kanchipuram district. Studies concerning the Ground Water potential of this area have been done by the Public Works Department ,Tamil Nadu in 1992. *(Draft Report of the Work Group on the estimation of Ground Water Resource and Irrigation Potential from Ground Water in Tamil Nadu -August,1992).* We shall use the data given in this study for our analysis.

Lathur Block is depicted as a Gray Block as far as the extent of ground water utilisation is concerned. It means, that 65-85% of the Ground Water available in this Block is being utilised currently.

The estimated Ground Water Recharge is about 1,55,50,000 m^3. The Utilisable Ground Water Recharge is 1,32,20,000 m^3. Out of this utilisable ground water recharge, about 95,50,000 m^3 was being used in 1992. This is about 72%.The balance ground water available for newer uses then was 36,70,000m^3. The demand for the remaining utilisable ground water was believed then to go up by about 3% the utilisable ground water value every 5 years.

This is an estimate that was made for *ideal* conditions; that is, this will be applicable whenever the monsoons are regular; but if the monsoons fail, then the total water available for all the users decreases dramatically.

Maduranthagam is the nearest Rain Gauge Station. An analysis of the Drought years at Maduranthagam will tell us whether the rains are regular or not in this area.

We shall analyse a 28 year period starting from the year 1971 to 1998. We note that the place witnessed a mild drought (*that is, when the range of the % of deviation (Di) from the long term annual mean rainfall is 0 to -25*) for 6 years (1973,1974,1980,1981,1990 and 1993). It witnessed moderate drought (*Di here is -25 to -50*) for 4 years (1979,1982,1987 and 1998). The number of years it witnessed Severe Drought (*Di < -50*) was 4 years (1986, 1988,1989 and 1997). This means that the rainfall in this area was deficient for 50% of the period. So for 50% of the period of study, we can not expect the Utilisable Ground Water Discharge to be as depicted above (for the *ideal* conditions). It should have been much lower than that of the depicted *ideal* value.

The PFBR is expected to be commissioned in the year 2009. Hence we can consider this to be the year from which the reactor will start drawing water from the Panankattuchery headworks. It is expected to have a lifetime of 45 years. That is, it will operate up to the year 2054.

Even without the PFBR in the scene, with the expected 3% increase in the ground water utilisation every 5 years, a 100% utilisation of the region's available ground water resource will be reached somewhere in the year 2040. With the PFBR in scene this will occur a bit earlier.

All this, as noted above, is only an *ideal* estimate; but *in reality*, with the drought occurring almost 50% of any given period, the situation will actually be different.

So, let us consider the ground water position in those 4 years when the region experienced a severe drought. As the rainfall was around 50% of the expected value in these years, the amount of the utilisable ground water recharge should have gone down accordingly. Hence, the utilisable ground water recharge for say the year 1997 should have been something around 66,10,000 m^3 (instead of 1,32,20,000 m^3); but the demand for that year was something around 99,46,600m^3. So, we notice that in the year 1997 itself, there was a shortage of Ground Water in this area of about 33,36,600 m^3. As the years pass, this shortfall will only increase during the periods of drought,

because the number of users would have increased dramatically.

The volume of ground water that the PFBR requires is 5,58,815 m^3 for one year (1,531m^3/d). This is about 4.23% of the *ideal* utilisable ground water recharge value; but during the times of severe drought, this will be something like 8.45% of the utilisable ground water value present at that time. How will the PFBR manage to increase this share when every user will be (like even a marginal farmer) craving for a little more additional water?

If we extrapolate the findings of the 28 year study to a future period of 45 years (that is the life time of the PFBR), we note that the number of severe droughts during this time period will be around 6 years; the number of moderate drought years will also be around 6 years. The number of mild drought years will be around 10 years.

How is the PFBR programme going to overcome this obstacle? By an iron willed authority? Or, by getting a consensus from the local population around, for increasing its share during the times of drought? Or still, by going in for other means of obtaining Fresh Water like from a Desalination Plant?

Whatever its strategy shall be, nothing about it is mentioned in the current MECON EIA; and it is based on this EIA, that the TamilNadu Pollution Control Board is expected to issue the licence for the construction of this Reactor!

What will the Tamil Nadu Pollution Control Board will do now?

Let us wait and see.

Chapter 12

How prepared are the people around Kalpakkam Nuclear Complex to meet an off-site emergency?

In 1992, *Makkal Ariviyal Iyakkam (Peoples' Science Movement)* conducted a survey among the people living within a radius of 16 km from the Kalpakkam Nuclear Complex; its objective was to know the people's preparedness in case of an emergency at the reactor complex. 35 villages and 21 panchayaths were surveyed (see map-) and a total number of 369 people were interviewed. The Report was finally published in the *Economic and Political Weekly (March 6,1993).*

The Survey presented the following findings:

1) Minimum Knowledge on Radiation and its Effects:

a) 13.6% of the people contacted within a radius of 5 km possessed a minimum clear knowledge. 11.1% and 12.9% were the value for the people living in the 5-8 km and 8 to 16 km zones.

2) Only about 6.7% among those who could not read or write possessed this knowledge. The value was 10.2% for those who could barely read and write, 16.7% for those who had studied up to 5th to 10th standards, and 23.8% for those who had education above 10th class.

3) 33.3% of the Forward caste people contacted possessed this minimum knowledge. The value was 13.4 for Backward castes, and 10.3 for the Scheduled castes.

4) 12.9% of the people below their 25 years of age possessed this knowledge. It was 14.2% for those between 25 to 35 years of age, and 10.8% for the above 35 years age group.

5) 14.1% of the interviewed men had this knowledge. NONE of the women possessed this knowledge.

2) Preparedness in case of a Nuclear Accident:

1) Only 5.5% of the people living within the radius of 5 km had a minimum clear knowledge on the required emergency preparedness in times of a reactor accident. This was 4.4% for the ones living within 5 to 8 km, and 3.6% for the people living in the 8 to 16 km zone.

2) It was very ironical to find that among the 21 individuals who had 10th standard and above education NONE of them possessed this minimum knowledge. The % of people who could not read or write but having this knowledge was 3.4%. It was 6.3% for those who could barely read or write. It was 5.3% for those who had education up to 5th to 10th classes.

3) The same irony was repeated when the team found that none of the 6 forward

caste respondents had this minimum knowledge. Backward caste respondents having this knowledge was 6% and among the scheduled caste respondents this was 2.8%.

4) 4% of the respondents below the 25 years age group had this minimum knowledge; This was 6.7% in the age group 25 to 35 years and 3.4% for those above 35 years.

5) 4.9% of the Male respondents and 2.3% of the Female respondents had this minimum knowledge.

The survey points out that they didn't know what to do (like what and what not to eat, where and where not to stay) during the time of a reactor accident. They didn't know how they will get the news of the accident. They had no idea of how and where they will be evacuated during an off-site emergency.

The EIA has not tried to conduct a similar survey. Instead it merely states: "*There is a well organised training programme being conducted at Kalpakkam. The training as at three levels, viz. villagers and high school students from the emergency planning zone, staff members who don't have a significant role in carrying out the emergency action plan, emergency response personnel consisting of staff members and service groups and district officials of the state agencies responsible for taking protective and remedial actions.*"

We know what will be the extent of the Damage if the People affected do not possess the knowledge necessary for managing the disaster they are put into. The recent Gujarat earthquake is an example for this. Merely stating that the Department is looking into every single thing concerned will NOT help.

How can the people who posses such a little knowledge on how to protect themselves during a nuclear accident react during a *Public Hearing* in which they will be expected to raise every kind of objection to a new reactor?

It definitely will be an unequal show.

Conclusion

We shall now summarise the most important findings of this *'Critique of the Mecon EIA'*:

1) The Mecon EIA's methodology is essentially Subjective. It has handled the available data selectively. Its choice of the data on various issues seems to have been guided by subjective factors rather than by the objective questions that are present in the field of study.(see chapters 8 and 9).

2) It is making scientifically incorrect and wrong statements on issues like 'the nature of the sea coast' in which Kalpakkam is located.(see chapter 6).

3) It has not considered some of the most important issues for analysis - like the 'Health and the Disease Profile of the local population', 'hydrological potential of the ground water source from where the fresh water for the reactor will be drawn'.

4) An Environmental Impact Assessment Study, gains its legitimacy only from the Scientific Methodology it bases itself upon; but, here we have a study which has wandered wildly from this basic principle.The Pollution Control Board should take note of this, and consider rejecting this EIA.

5) Commissioning a repeat EIA may not help at the present time. This is because, some of the studies that are pertinent for understanding the possible impacts of this project are non existent. The seismo-tectonic features of this region, the nature of sea erosion that this site is subjected to, the *real* (and not the *ideal*) hydrological potential of the region, the health impacts of the nuclear reactors existing in this place are some of the more important studies that have not been done or have been done only partially. Hence, conducting these Studies will be the first step; only after the results of these studies are available, another EIA may be commissioned for this reactor.

6) This *'Critique..'* has hypothesized that the Scientists, Engineers and their Family members living at the DAE Quarters are exposed to the Maximum Risk of contracting to various types of Cancers(Chapter 9). Proving this hypothesis right or wrong should be given the Top Priority now. The Tamil Nadu Pollution Control Board, after rejecting the Mecon EIA, should then ask the AEC to allow an *independent* team of scientists to undertake this study on the incidence of various types of Cancers in the DAE Quarters.

Bibliography

Alexander, F.E, Cartwright, R.A, Mac Kinnon, P and Ricketts, T.J, 'Leukemia incidence, social class and estuaries: an ecological analysis', *Journal of Public health medicine,* 12, 109-117, (1990)

Andrew Koch, Christopher Derrick, and Shelby McNichols, "Selected Indian Nuclear Facilities" (July 1999), Monterey Institute of International Studies.

Beral et al., 'Mortality of employees of the United Kingdom Atomic Energy Authority, 1946-1979', *BMJ (Clin Res Ed)* 1985 Aug 17; 291(6493):440-7)

Chris Busby et al, 'Cancer Mortality and Proximity to Bradwell Nuclear Power Station in Essex, 1995-1999', Green Audit: Aberystwyth, March 2001

Chris Busby et al, 'Cancer Mortality and Proximity to Hinkley Point Nuclear Power Station 1995-1998, Parts I &II', Green Audit: Aberystwyth, 2000

Chris Busby et al., 'Cancer Mortality and Proximity to Oldbury Nuclear Power Station in Gloucestershire 1995-1999, Occasional Paper 2001/6', Green Audit: Aberystwyth, April 2001

Chris Busby, (1998a), 'Childhood leukemia and radioactive pollution from the Atomic Weapons facilities at Aldermaston and Burghfield in West Berkshire: Causation and Mechanisms' Occasional Paper 98/1, Aberystwyth: Green Audit

Compilation of Nuclear Accidents from the year 1945-1991, by Awareness Education for the Office of Jo Vallentine Senator for The Greens (WA), Australia

Cook-Mozzafari P.J, Darby,SC. Doll R, Forman D, Hermon C, Pike MC, Vincent T (1989), 'Geographical variation mortality from leukemia and other cancers in England and Wales in relation to proximity to nuclear installations 1969-78' *Br.J.Cancer* 59: 476-85

Draft Report of the Work Group on the estimation of Ground Water Resource and Irrigation Potential from Ground Water in Tamil Nadu -August,1992

Draper et al., 'Cancer in the offspring of radiation workers: a record linkage study', *BMJ*,1997; 315:1181-1188(8 Nov)

Economic and Political Weekly (March 6,1993)

Harvey Wasserman & Norman Solomon, 'KILLING OUR OWN-The Disaster of America's Experience with Atomic Radiation'

Hoffmann W., Greser E.(1998), "Epidemiologic evaluation of leukemia incidence in children and adults in the vicinity of the nuclear power plant Kruemmel(KKK)"in Schmitz-Feuerhake I and Schmidt MM, *Radiation Exposures by Nuclear Facilities, Proceedings of an International Workshop, Gessellschaft fuer Strahlenschutz, Portsmouth, England 1996* (Bremen:Gessellschaft fuer Strahlenschutz)

Indian Express, 13-01-2000

Kinlen L.J et al., 'Can parental preconceptional radiation account for the increase of leukemia and non-Hodgkin's lymphoma in Seascale?', *BMJ*, 1993, Jun 26;306(6894):1718-21

Krishna Brahmam.N., 'Gravity in Relation to Crustal Structure, Paleo-Sutures and Seismicity of Southern India (South of the 16th parallel)', *Memoir Geol.Soc.India*, No.25,

Loeke Pam et al., 'The MOX Myth -The dangers and risks in the use of mixed oxide fuel', *wiseamster@antenna.nl,* April 1997

Marine Protected Area Needs in the South Asian Seas Region,Vol-2:India*,* ed., John C.Pernetta, IUCN, 1993

Mauricio Schoijet, 'Sociology of Nuclear Accident-Facts and Conjecture', in Philosophy and Social Action, 26(4)2000

Mishra D.C., et.al., 'Thickening of Crust under Granulite Province of South India **and** Associated Tectonics Based on Gravity-Magnetic Study', in *Memoir Geol. Soc.of India,* No.25,

Nuclear Europe Worldscan, no.1-2 1993: 'UK plans orderly, scientific withdrawal from fast reactor R&D'

Paul J et al., 'Microstrain stability of Peninsular India 1864-1994', in *Proc.Indian Acad.Sci. (Earth Planet Sci)* Vol. 104, No.1, March 1995

Pearl Marshall, "India and France Renew Old Friendship," *Nucleonics Week*, 4 July 1985

Ramana M.V, 'Dangerous encounters', in *The Hindu*, 21-11-1999

Ramasamy S.M., et.al., 'Remote sensing and Pleistocene tectonics of Indian Peninsula', in *Int.J.Remote Sensing* ,1995, vol.16,no13.

Roman et al, 'Case-control study of leukaemia and non-Hodgkin's lymphoma among children aged 0-4 years living in west Berkshire and north Hampshire health districts'. *BMJ 1993; 306: 615-621*

Sambasiva Rao M, 'Some aspects of morphology and quartenary sea level changes in coromandel coast of TamilNadu and Andra Pradesh' in 'Sea level variation and its impact on coastal environment' ed., G.Victor Rajamanickam, Tamil University, Thanjavur, p,287-288

SCRAM Journal (Scotland) March/April 1988

Smith PG et al, 'Mortality of Workers at the Sellafield plant of British Nuclear Fuels (1947-1975)', *BMJ (Clin Res Ed)* 1986 Oct 4; 293 (6551): 845-54)

"Source Book: Soviet-Designed Nuclear Power Plants in Russia, Ukraine, Lithuania, Armenia, the Czech Republic, the Slovak Republic, Hungary and Bulgaria" Fifth Edition , 1997, Nuclear Energy Institute Suite 400 1776 I Street, N.W. Washington, DC

The Hindu,March 22, 2001

U.S. NRC Regulatory Guide DG-1015 (USNRC, 1992a)

USGS, National Earthquake Information Centre's database

Vemban et al., 'Major faults/dislocations/lineaments of Tamilnadu', Geological Survey of India. 1977, Miscellaneous Publication. 31

Victor Rajamanickam G, ed., 'Sea level variation and its impact on coastal environment', Tamil University, Thanjavur

Viel, J.F and Poubel, Dominique, (1997), 'Case Control Study of Leukemia among young people near the La Hague reprocessing plant: the environmental hypothesis revisited.' *British Medical Journal* 14: 101-6

Vyvyan Tenorio, "India's 40-MWt FBTR Went Critical Late Last Week," *Nucleonics Week*, 24 October 1985

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